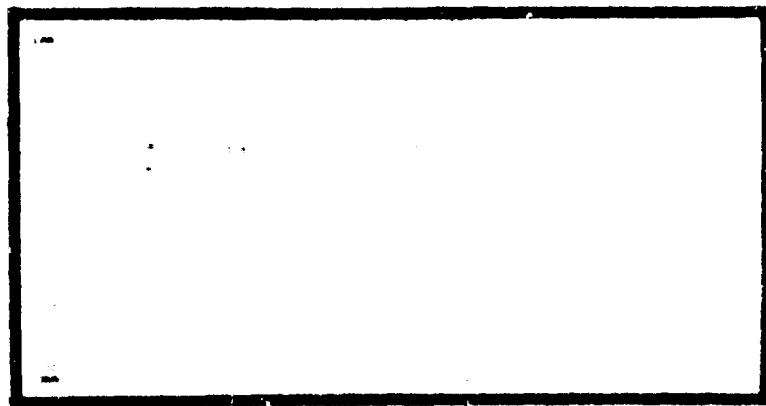


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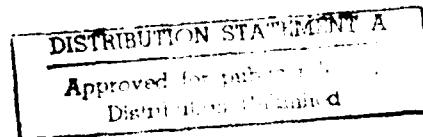


LIFE CYCLE COSTING: A WORKING
LEVEL APPROACH

Anthony T. Cira, Captain, USAF
Kenneth R. Jennings, Captain, USAF

LSSR 37-81

JUN 1981



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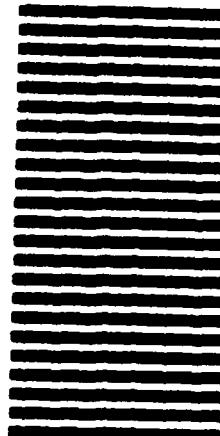


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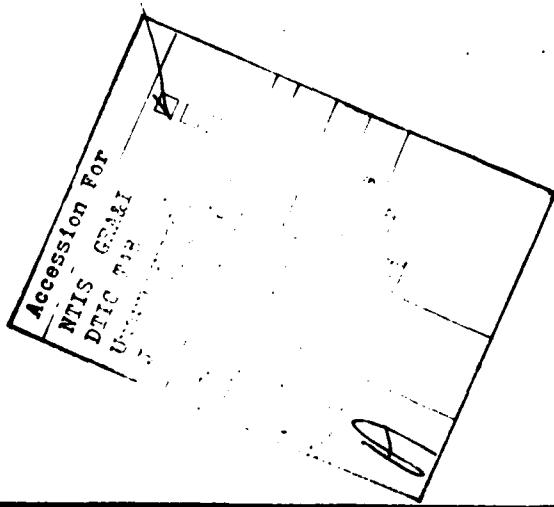
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Life Cycle Costing (LCC) is an attempt to integrate the concepts of reliability, maintainability, design-to-cost, and integrated logistic support into a management tool designed to aid program managers fulfill their system acquisition responsibilities, particularly with regard to reducing a system's cost of ownership. Increasing emphasis on LCC has resulted in a plethora of DOD/USAF directives, instructions, regulations, pamphlets and guides. This thesis attempts to integrate the various LCC requirements, procedures, and techniques currently available from a wide variety of sources (including many unpublished documents) into a management framework that can be used by the working level program manager to implement LCC in any major system acquisition program.



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A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

in Partial Fulfillment of the Requirements for the
Degree of Master of Science in Logistics Management

By

Anthony T. Cira, BS
Captain, USAF

Kenneth R. Jennings, BS
Captain, USAF

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This thesis, written by

Captain Anthony T. Cira

and

Captain Kenneth R. Jennings

has been accepted by the undersigned on behalf of the
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R. J. Blumenthal
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TABLE OF CONTENTS

	Page
LIST OF TABLES	x
LIST OF FIGURES	xi
Chapter	
I. INTRODUCTION	1
Problem Statement	1
Background and Literature Review	2
Justification	6
Objective	7
Definitions	7
Research Questions	8
II. METHODOLOGY	9
Problem Orientation	9
Document Review	11
Interviews	12
Data Analysis	12
Result	13
III. DOCUMENT REVIEW	15
DOD Directives	16
DOD Summary	24
Air Force Documents	27
Air Force Summary	36

Chapter	Page
IV. DATA ANALYSIS	38
Method of Presentation	40
LCC Models	44
Description	44
Advantages	47
Disadvantages	47
Information Sources	48
Conceptual Phase	48
LCC Assessment	48
Specialist Estimate	49
Specific Analogy	50
Risk Analysis	51
Life Cycle Cost (LCC) Model--A Cost Estimating Relationship (CER)/Parametric Model	51
USAF Cost and Planning Factors	53
Development of an Acquisition Approach . .	53
Cost-Benefit Analysis/Cost- Effectiveness Analysis	54
Life Cycle Cost Implications of Requirements	55
LCC Models	55
Cost Sensitivity Analysis	55
Determining the Employment, Support and System Concepts	56
Level of Repair Analysis/Optimum Repair Level Analysis (ORLA)	57

Chapter	Page
Logistics Support Analysis (LSA)	57
Maintenance Engineering Analysis (MEA) . .	58
Failure Mode and Effects Analysis (FMEA)	59
Logistics Performance Factors (LPFs) . . .	60
Planning the Use of Life Cycle Cost in the Demonstration & Validation Phase Source Selection	61
Conceptual Phase Summary	61
The Acquisition Process	61
The Weapon System	62
The Working Level LCC Manager	62
Demonstration and Validation Phase	63
Validation Phase LCC Trade Studies	63
Cost-Benefit Analysis/Cost Effectiveness Analysis	63
LCC Model	65
Cost of Ownership Refinement	65
Engineered Cost Estimating Method	65
Industrial Engineering Standards (IES) .	67
Specialist Estimates	68
Specific Analogy	68
USAF Cost and Planning Factors	68
Cost Sensitivity Analysis	68
LCC Model--An Accounting Type	68
Refinement of the Acquisition Approach . .	68

Chapter	Page
LCC Model	68
Award Fee	69
LCC Verification Test Plan	70
Demonstration and Validation Phase Summary	73
The Acquisition Process	73
The Weapon System	73
The Working Level LCC Manager	74
Full Scale Engineering Development Phase . .	74
Detailed System and Support LCC Design Trade Studies	76
Level of Repair/Optimum Repair Level Analysis	76
LCC Model	77
Failure Modes and Effects Analysis . . .	77
Cost of Ownership Refinement	77
LCC Model (Accounting)	77
Engineered Cost Estimating Method . . .	77
USAF Cost and Planning Factors	77
Cost Sensitivity Analysis	77
Risk Analysis	77
Planning the Use of LCC in Source Selection and Negotiation	77
Learning Curve Analysis	78
LCC Model	79
Pre-Award Testing	81

Chapter		Page
Development of Warranties/Guarantees	82	
Inspection of Supplies and Correction of Defects (DAR 7-203.5)	83	
Warranty of Supplies for Ordinary Equipment and Complex Supplies (DAR 7-105.7)	84	
Correction of Deficiencies (COD) (DAR 7-105.7)	84	
Warranty of Technical Data (DAR 7-104.9)	85	
Rewarranty of Repaired/Overhauled Equipment	85	
Repair/Exchange Agreements	86	
Reliability Guarantee	87	
Reliability Improvement Warranty (RIW) .	87	
Mean Time Between Failure Verification Test (MTBF-VT)	88	
Availability Guarantee	88	
Logistics Support Cost Guarantee	89	
Software Design Commitment	90	
LRU Configuration Control and Support Agreement	90	
Full Scale Engineering Development Phase Summary	91	
The Acquisition Process	91	
The Weapon System	91	
The Working Level LCC Manager	91	
Production Phase	92	
Engineering Change Proposal (ECP) Review and LCC Verification	92	

Chapter		Page
	LCC Model	94
	LCC Verification Test Plan	95
	Production Phase Summary	95
	The Acquisition Process	95
	The Weapon System	95
	The Working Level LCC Manager	96
V. LCC--A WORKING LEVEL APPROACH		98
	Working Level LCC Manager Qualifications . .	99
	LCC Philosophy	102
	Conceptual Phase (MENS-DSARC I)	104
	LCC Activities During Conceptual Phase . . .	110
	Demonstration and Validation Phase	127
	LCC Activities During the Demonstration and Validation Phase	127
	Full Scale Engineering Development Phase . .	130
	LCC Activities During the Full Scale Engineering Development Phase	132
	Production Phase	137
	LCC Activities During the Production Phase	137
VI. FINDINGS AND RECOMMENDATIONS		139
	Finding: The Working Level LCC Manager . . .	141
	Recommendation: The Working Level LCC Manager	146
	Finding: The Data Problem	147
	Recommendation: The Data Problem	148

	Page
Future Changes	149
Recommendations for Further Research	150
LCC Personnel Policies	150
"How-to" Guidance	150
Data System Integration	151
Software Acquisition	151
APPENDICES	153
A. INTERVIEW GUIDE	154
B. VAMOSC II	164
C. ACRONYMS	169
SELECTED BIBLIOGRAPHY	173
A. REFERENCES CITED	174
B. RELATED SOURCES	178

LIST OF TABLES

Table	Page
1. DPC Annex C: Life Cycle Cost	20
2. IPS Areas of Discussion	21
3. DSARC Milestone Planning Schedule	23
4. Procedures and Techniques by Phase	41
5. PMP and AP Sections	108
6. RFP Format	122

LIST OF FIGURES

Figure	Page
1. Thesis Logic Process	10
2. Defense System Acquisition Review Council (DSARC) Process	18
3. DOD LCC Requirements	25
4. DOD/USAF LCC Requirements	37
5. DSARC Phases	38
6. Conceptual Phase Requirements and Procedures	64
7. ACF/F-16 LSC Model Application (Contractual Commitments)	72
8. Demonstration and Validation Phase Requirements and Procedures	75
9. Full Scale Engineering Development Phase Requirements and Procedures	93
10. Integration Chart: Requirements and Procedures	97
11. Typical SPO Organizational Structure	100
12. LCC Oriented Inclusions in the Request for Proposal (RFP)	121
13. Conceptual Phase Requirements and Procedures	126
14. Demonstration and Validation Phase Requirements and Procedures	131
15. Full Scale Engineering Development Phase Requirements and Procedures	136
16. Method of Investigation	140

Figure	Page
17. Integration Chart: Requirements and Procedures	142
18. Life Cycle Costing in System Acquisition . .	145
19. VAMOSC II	167

CHAPTER I

INTRODUCTION

Problem Statement

DOD Directive 5000.1, "Major System Acquisition," directs that

... each DOD official who has direct or indirect responsibility for the acquisition process . . . shall make every effort . . . to achieve the most cost effective balance between acquisition cost and ownership cost and system effectiveness [37:2].

A further guidance for cost management is found in DOD Directive 5000.2, "Major System Acquisition Procedures," when it states

... a life cycle cost estimate shall be prepared at Milestone 1, using the best available data and techniques. An updated life cycle cost estimate shall be provided for each subsequent Milestone [38:4].

Additionally, DOD Directive 5000.28, "Design to Cost," defines design to life cycle cost as the overall goal of the design to cost concept (35:3). In response to these directives, the Air Force and the acquisition community have published a multitude of regulations, guides, and implementation instructions pertaining to the management of a life cycle cost program during the acquisition of a major weapon system. The problem is that the person at the working level who must implement and manage a life cycle cost program finds this volume of documentation too

broad and philosophical for effective program use. A need exists to analyze the current DOD and USAF regulations and implementation instructions, as well as organizationally generated documentation, to provide the working level manager with a guide outlining the requirements and procedures for implementing and managing a Life Cycle Cost program during a major weapon system acquisition.

Background and Literature Review

Since the end of World War II, acquisition costs have increased as newly developed systems have grown in complexity. Additionally, this increase in system complexity has generated higher operating and support (O&S) costs which represent an increasing share of the total weapon system cost. O&S cost represented 70 percent of the total cost in 1974, as opposed to 1965 when O&S costs represented only 50 percent (14:4). At the same time, the DOD share of the Federal Budget has gone from 50 percent in 1960 (22:78) to just over 25 percent in 1980 (23:5).

Increased acquisition and operating and support costs have caused great concern within DOD and the acquisition community. This concern centers around pressure to produce a weapon system that meets the performance specifications, but at the same time is cost effective. In the past, emphasis on the need for improved performance to meet new or growing threats, or to take advantage of changes in

technology lessened the importance of cost as a primary consideration in the acquisition of the weapon system. Typically, those costs most visible (acquisition and research, development, test and evaluation costs) received the greatest management attention. Concern over the program being within budget and not on the cost overrun list resulted in operating and support costs being virtually ignored. The problem is that decisions made to improve performance during the acquisition phase have long-term effects on operating and support costs over the life cycle of the weapon system. It has been suggested that by the end of the Demonstration and Validation Phase of the Defense System Acquisition Review Council (DSARC) process, 85 percent of the total life cycle costs of a weapon system have been determined (7:36). It is this dilemma of increasing costs and shrinking DOD O&M funds that led to the 1971 version of DOD Directive 5000.1, making the cost of operating a weapon system an equal partner with performance and schedules; hence the birth of Life Cycle Costing (LCC) (36:4).

Life Cycle Costing is an attempt to integrate the concepts of Reliability, Maintainability, Design-to-Cost, and Integrated Logistics Support into one management tool. LCC is a management tool that enables the program manager to consider all costs of ownership as well as research and development and acquisition cost during the procurement of

a weapon system. An example of the advantages of Life Cycle Costing was demonstrated when the Air Force procured the ARC-164 UHF aircraft radio (6:29). Through the consideration of balancing performance, acquisition costs, and ownership costs, the Air Force procured a radio that achieved a tremendous increase in reliability at a substantial reduction in total ownership costs (approximately \$1M/month) (6:31). Since this effort in 1972, the use of Life Cycle Costing as a management tool to control ownership costs has received increased emphasis from DOD policy makers. Life Cycle Costing was first utilized for a major aircraft weapon system acquisition during the procurement of the A-10 aircraft. This initial effort considered the entire program under LCC concepts and served as an experiment to document some of the problems that would be encountered in applying Life Cycle Costing techniques (e.g., the AFLC O&S Cost Model) to a major weapon system acquisition (17:2). Following this initial attempt, Life Cycle Costing techniques played a major role in the source selection process for the ACF/F-16 aircraft (20). In a research effort, Davis and Wysowski analyzed the application of Life Cycle Costing techniques (including the AFLC Logistics Support Cost Model) to the ACF/F-16 weapon system acquisition. Cited within their effort is the need to consider LCC techniques and strategies early in the acquisition process (9:89) and the need for qualified personnel,

knowledgeable in LCC management strategies to advise the Program Manager on possible Life Cycle Cost opportunities. Additionally, in their suggested areas for future research, Davis and Wysowski documented the need for a set of guidelines that could be used for implementing and managing a Life Cycle Cost program during each phase of the acquisition process (9:93).

Currently, there are a number of "how-to" type guides in the field aimed at assisting the LCC working level manager. The Life Cycle Cost Procurement Guide and The Life Cycle Cost Analysis Guide are available through the LCC Management Group, ASD/ACCL. In addition, the Air Force Institute of Technology publishes an LCC textbook. The guides, as a whole, offer a good overview of the acquisition process and introduce a number of procedures and techniques important to the LCC manager. However, the latest guide was published in 1976 and some of the terminology is outdated. Additionally, practical examples are lacking for the procedures and techniques cited. Using these guidelines alone, a new LCC manager would find it difficult to synthesize the specific requirements of his task, and determine the tools .. might use to accomplish these requirements.

Justification

There are numerous reasons for this research effort into the working level management of a Life Cycle Costing program and derivation of a guide outlining the requirements and procedures for implementing and managing an LCC program during a major weapon system acquisition.

1. Inexperience. The Air Force Officer corps, prime candidates for the working level LCC management job, are increasingly composed of junior officers. An inexperienced manager, such as this, would stand to benefit most from the practical guidance documented in this research effort.

2. None Currently Available. There is no implementation guide structured toward the working level manager that can be used to guide the manager through the DSARC process and the LCC activities that should be implemented during each phase.

3. Inclusion of Current Field Experience. The need exists to discover what resources, pitfalls, and workflows are known by LCC managers. Pooling this "field tested" knowledge with "lesson learned" data from AFALD/PT will create a valuable source of practical information concerning the success/failure of current and past LCC endeavors.

4. Significant Government Investment at Stake. The success of current and future LCC programs will

determine the savings or loss of literally millions of dollars in system ownership costs.

Objective

The objective of this research effort is to provide the working level manager with a guide outlining the requirements, procedures, and techniques for implementing and managing a Life Cycle Cost program during each phase of the major weapon system acquisition process.

Definitions

For purposes of this research effort the following terms which were specified in the objective statement must be defined:

1. Requirement. A requirement is a task that can be documented to a specific regulation, directive, or policy letter.
2. Procedure. A procedure is a particular course of action or established mode of operation that is used to complete some requirement.
3. Technique. A technique, employed during the application of a procedure, is the methodology utilized by an individual, to satisfy a particular task or requirement. This may be an established method of accomplishing a task or an heuristic generated by the individual, generally more specific in nature than a procedure.

Research Questions

In order to meet the objective stated above, the following research questions must be answered:

1. What specific Life Cycle Cost requirements concerning major weapon system acquisition are identified in DOD/USAF directives?
2. What procedures and techniques are currently documented to assist the Life Cycle Cost manager in meeting these requirements?
3. What procedures and techniques have been and are being used by Life Cycle Cost managers in the field to design and implement a Life Cycle Cost program?
4. Based on the data gathered, what management actions should the working level Life Cycle Cost manager take to fulfill the requirements of Design to Life Cycle Cost during the process of acquiring a major weapon system?

CHAPTER II

METHODOLOGY

This chapter describes the methodology by which the research questions in Chapter I will be answered. The task, in answering the research questions, was principally one of designing and enacting a data collection and organizational system that would ensure total and accurate coverage of the questions. Figure 1 depicts the logic process by which the data was collected and organized. It was through this logic process that the research team ensured complete and accurate coverage of the data that was germane to the problem (see Figure 1).

Problem Orientation

Initial orientation to the research problem area was accomplished in the following ways:

1. The research team informally interviewed LCC experts in AFALD/XR and ALD/ASD LCC Joint Working Group to become familiar with problems (from their viewpoints) that are common in Life Cycle Costing application to major weapon system acquisition.
2. The research team reviewed the research concerning Life Cycle Costing application to a major aircraft weapon system (A-10, F-16) as documented by Bell and Turney

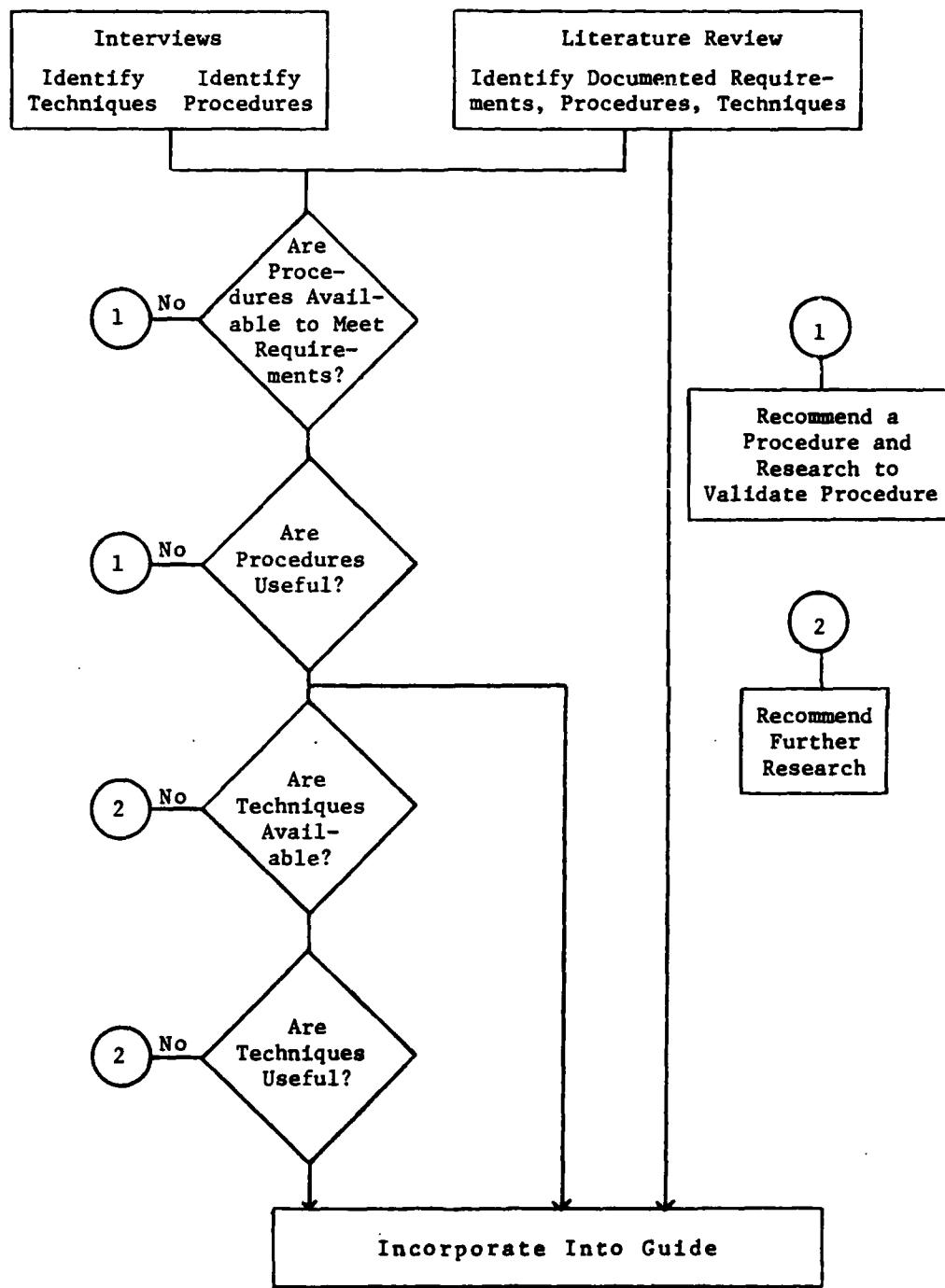


Fig. 1. Thesis Logic Process

(A-10) and Davis and Wysowski (F-16). These two efforts documented the first attempt by the Air Force to implement LCC procedures and techniques on a total weapon system program (9; 4).

3. The research team conducted interviews with personnel who were currently involved in LCC application to major weapon system acquisitions. This effort enabled the research team to gain first-hand knowledge of the problems that were currently being experienced when applying LCC techniques to a major weapon system acquisition and provided further guidance into potential research areas.

Document Review

This portion of the research effort was dedicated to extracting requirements, procedures, and techniques currently documented in DOD and USAF regulations, LCC implementation guides published by the ASD/ALD Joint LCC Working Group, technical reports, formal research and periodical articles. The intent of the research team was to analyze this body of literature, breaking down the information contained in each document into a format mable to further data manipulation and analysis. The first step was to categorize the applicable data into the proper phases of the DSARC Milestone process, so as to identify, in a time sequence, the requirements that influence the working level LCC manager. Each requirement was then

associated with those procedures and techniques documented in the literature. This process was followed until the research team had a comprehensive list of requirements for each phase of the DSARC process, and a subsequent listing of available procedures and techniques that could be utilized to meet those requirements; all of which were documented in a specific regulation, implementation guide, technical report, formal research report, or periodical.

Interviews

The interview portion of this research effort was a critical follow-on to the literature review analysis. The target group for the interviews were current LCC working level managers, and LCC experts, who were involved in major weapon system acquisition programs. Each group of individuals identified previously, was interviewed to determine what procedures and specific techniques were utilized to fulfill the requirements identified in the literature review. Additionally, the target group was asked to subjectively judge the success of the procedures and techniques identified in the literature review and the success of their own procedures and techniques in fulfilling the documented requirements.

Data Analysis

The information obtained from the literature review and interviews was combined and analyzed. The primary

concern was to determine whether a procedure or technique was available to fulfill a documented requirement. Procedures identified during the literature review and the interviews were matched against the documented requirements. Each procedure was then subjected to a test for usefulness. For the purpose of this research effort, a useful procedure was one that was simple in nature, economical, easy to understand, could be used in a timely manner, and successfully fulfilled the requirement. Economical considerations were based on the cost of personnel and data processing time and support.

The second focus of the analysis was on the availability and adequacy of specific techniques utilized to facilitate procedure application. Initially, each procedure identified was analyzed in terms of the specific techniques required to implement that procedure. If a procedure existed for which a needed technique did not exist, the research team made a recommendation that future research be directed toward supplying the needed technique.

Result

The outcome of the analysis of the literature review and interviews is a body of data describing the requirements, procedures, and techniques, organized into the appropriate phases of the DSARC process. In effect this data forms a system of LCC requirements by DSARC

Phase and respective procedures and techniques that a working level manager can use to design and implement an LCC program during each phase of a major weapon system acquisition.

CHAPTER III

DOCUMENT REVIEW

This chapter addresses the research question of what specific Life Cycle Cost (LCC) requirements concerning major weapon system acquisition are identified in DOD/USAF documents. It must be understood that the requirements that are identified in this chapter deal only with major weapon system acquisition and specifically identify an LCC requirement. The purpose of this chapter is to ascertain what the documents specify as LCC requirements and the level of integration that the documents attach to the concept of Life Cycle Costing during the acquisition process.

The requirements identified in this chapter were gathered through an initial examination of any DOD Directives/Instructions (DODD/Is) that might pertain to any facet of the acquisition process. Those DODD/Is selected were then used as a basis to locate an Air Force Regulation (AFR) that implemented the DODD/I. During this review of DODD/Is and AFRs, any reference to the Defense Acquisition Regulation (DAR) was fully researched and documented.

Each Air Force regulation identified led to a subsequent review of Air Force manuals/pamphlets, Air Force Systems Command (AFSC), Air Force Logistics Command (AFLC),

Air Force Aeronautical Systems Division (ASD), and Air Force Acquisition Logistics Division (ALD) regulations, manuals, pamphlets, policy letters, and supplements to Air Force regulations. The last documents researched were the military standards (MIL-STDs) referenced in any of the previously mentioned documents. Again, it must be stated that this research was accomplished to ascertain what specific LCC requirements are addressed in this multitude of documents associated with the acquisition process, most or all of which must be dealt with by the working level LCC manager.

Each requirement that is cited will be assigned a place on a time line with the DSARC milestones representing major division points. The purpose of this time line is to provide order to the requirements defined and to provide a mechanism with which to discuss the integration of those LCC procedures and techniques (covered in the next chapter) with the requirements identified.

DOD Directives

OMB Circular A-109, the document which establishes the overall policy to be followed by all executive branch agencies in the acquisition of major systems, defines Life Cycle Cost as:

. . . the sum total of the direct, indirect, recurring, nonrecurring, and other related costs incurred, or estimated to be incurred, in the design, development,

production, operation, maintenance and support of a major system over its anticipated useful life span [40:3].

This definition, although not dealing with any specific requirement, is important in that it defines the scope of the concept of Life Cycle Costing for the working level manager. The Circular, in subsequent paragraphs, directs that the management of major system acquisition maintain the capability to estimate life cycle costs during system design, concept evaluation and selection, full scale development, facility conversion, and production to ensure appropriate tradeoffs among investment costs, ownership costs, schedules, and performance (40:5). This particular guidance requires the working level LCC manager to be involved in all phases and areas of the acquisition process, thus implying that he must be able to fully integrate LCC with the other divisions in the System Program Office (SPO).

DOD Directive 5000.1, "Major System Acquisition," is the implementing directive of OMB Circular A-109 for the Department of Defense (DOD). The DOD uses this directive to issue more specific guidance to the four services on the management of the major weapon system acquisition process. This directive dictates that logistics supportability will be a design parameter equal in status to cost, schedule, and performance (37:4). Although Life Cycle Cost is not specifically mentioned in this directive, the requirement of balancing cost, schedule, performance, and

logistics supportability leads to the consideration of Life Cycle Cost management. DODD 5000.1 further lays out the decision-making process that will be utilized during major weapon system acquisition. The process is divided into four phases (Figure 2) with major milestones (decision points) between each phase.

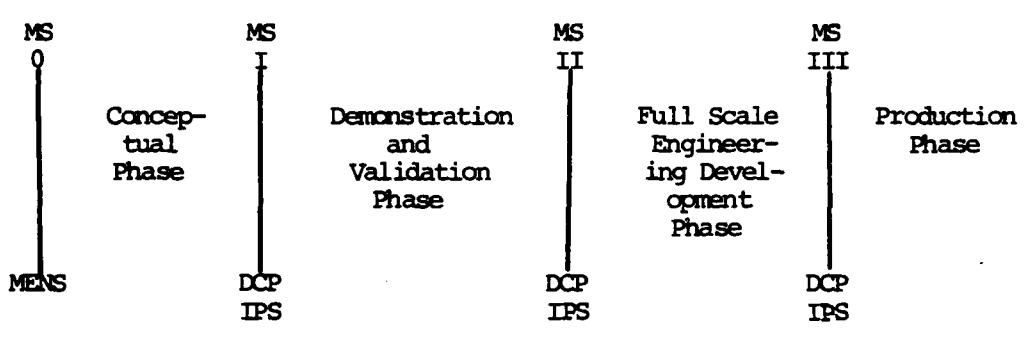


Fig. 2. Defense System Acquisition Review Council (DSARC) Process

At Milestones I, II, and III, the SPO in coordination with DOD and the Air Staff, is deeply involved in formulating the Decision Coordinating Paper (DCP) and Integrated Program Summary (IPS). These two documents are utilized by the Defense System Acquisition Review Council (DSARC) to serve as a management tool in reaching a decision about the program at each milestone. It is this acquisition process that all subsequent directives, regulations, manuals, and pamphlets refer to and from which further requirements are generated.

DOD Directive 5000.2, "Major System Acquisition Procedures," is the implementing directive of DODD 5000.1 and establishes the procedures that will be followed by the DOD components during the acquisition of a major weapon system. The Directive states that an LCC estimate will be prepared by Milestone 1 and updated at each subsequent milestone (38:11). The LCC estimate is part of the DCP and takes the form of an annex as depicted in Table 1. The second document required during the DSARC review is the Integrated Program Summary (IPS). The IPS summarizes the implementation plan that the DOD component plans to utilize during the acquisition program with major emphasis on the phase the program is entering. This document addresses the twenty-two items listed in Table 2.

Life Cycle Cost is addressed in the Cost category of the IPS and the directive dictates that the underlying assumptions pertaining to all life cycle cost estimates, including the impact of Foreign Military Sales, cooperative development or production, planned production rates, and learning curves for each alternative identified in the DCP be fully discussed (38:30). This directive, also, dictates, under the Cost category, that proposed Design-to-Cost goals and how they are to be implemented at the contract level be discussed. These two documents, the DCP and IPS, are the primary management tools by which senior

TABLE 1
DCP ANNEX C: LIFE CYCLE COST (38 : Enc1 4)

Alternative	Current Dollars (in millions)			Operating and Support	Total
	Development	Production			
A 1					
A 2					
A 3					
o					
o					
o					
Current Dollars (in millions)					
Alternative	Current Dollars (in millions)			Operating and Support	Total
	Development	Production			
A 1					
A 2					
A 3					
o					
o					
o					

TABLE 2
IPS AREAS OF DISCUSSION [34:Encl 4)

1. Program History
2. Program Alternatives
3. Cost Effectiveness Analysis
4. Threat Assessment
5. System Vulnerability
6. Organizational and Operational Concept
7. Overview of Acquisition Strategy
8. Technology Assessment
9. Contracting
10. Manufacturing and Production
11. Data Management
12. Configuration Management
13. Test and Evaluation
14. Cost
15. Logistics
16. Reliability and Maintainability
17. Quality
18. Manpower
19. Training
20. Facilities
21. Energy, Environment, Health, and Safety
22. Computer Resources

staff at the DOD and Air Staff level make decisions concerning the acquisition of a major weapon system.

These documents are prepared by the SPO management prior to the DSARC review. A schedule of events (Table 3) has been established for this process. It is this schedule of events and the information and documentation required to meet these events that will have a major effect on the working level LCC manager. As depicted in Table 3, the fifth item is a presentation by the Program Manager to the OSD Cost Analysis Improvement Group (CAIG). The format of this presentation is governed by DODD 5000.4. The presentation is an effort to explain how the Program Office and Independent Cost Analysis estimates of total program costs were prepared. The presentation must cover all elements of life cycle cost to include research and development, investment, and operating and support costs (39:5). A Cost Development Guide published by the CAIG office gives further guidance as to the level of breakdown of operating and support cost that must be presented during the briefing (33).

Within the Cost category of the Integrated Program Summary, the concept of Design-to-Cost (DTC) goals and how they will be implemented in the program must also be discussed. DOD Directive 5000.28, "Design-to-Cost," is the directive which dictates policy regarding DTC implementation. One of the directive's objectives is to establish

TABLE 3
DSARC MILESTONE PLANNING SCHEDULE (38:6)

Event	Schedule in Relation to Date of DSARC Meeting
1. Milestone Planning Meeting	- 6 months
2. For Comment DCP and IPS	- 3 months
3. DCP Comments to DOD Components	- 2 months
4. Final DCP and Update to IPS	- 15 workdays
5. OSD Cost Analysis Improvement Group (CAIG) Briefing	- 15 workdays
6. OSD Test and Evaluation (T&E) Briefing	- 15 workdays
7. OSD Manpower and Logistics Analysis (M&LA) Briefing	- 15 workdays
8. Defense Intelligence Agency Report to DSARC Chair	- 10 workdays
9. DSARC Chair's Pre-Brief Meeting (OSD Staff Only)	- 5 workdays
10. CAIG Report	- 3 workdays
11. T&E Report	- 3 workdays
12. M&LA Report	- 3 workdays
13. DSARC Meeting	- 0

cost elements as management goals for acquisition managers and contractors to achieve the best balance between life cycle cost, acceptable performance, and schedule (35:2). The directive dictates that LCC objectives will be established for each acquisition and separated into cost elements within the broad categories of development, production, operation and support, which will be firmed into cost goals to which the system will be designed and costs controlled (35:3). The directive further specifies that LCC estimates will be used as the basis for cost tradeoff analysis when considering acquisition versus operating and support costs, comparing prototypes, or comparing current versus new systems (35:4). The directive indicates that an estimated DTC goal will be submitted by DSARC 1, with firm DTC goals submitted by DSARC 2. Within each DTC goal formulated, the directive states that at the DSARC review, each DTC goal will be evaluated on a life cycle cost basis with emphasis on how LCC elements will affect source selection, contract incentives, use of cost models, and warranties.

DOD Summary

Thus far, the requirements identified at the DOD level have been general in nature, except in the area of documentation required for the DSARC review. A reason for this lack of specificity may be due to the application of these directives to all four services. Figure 3

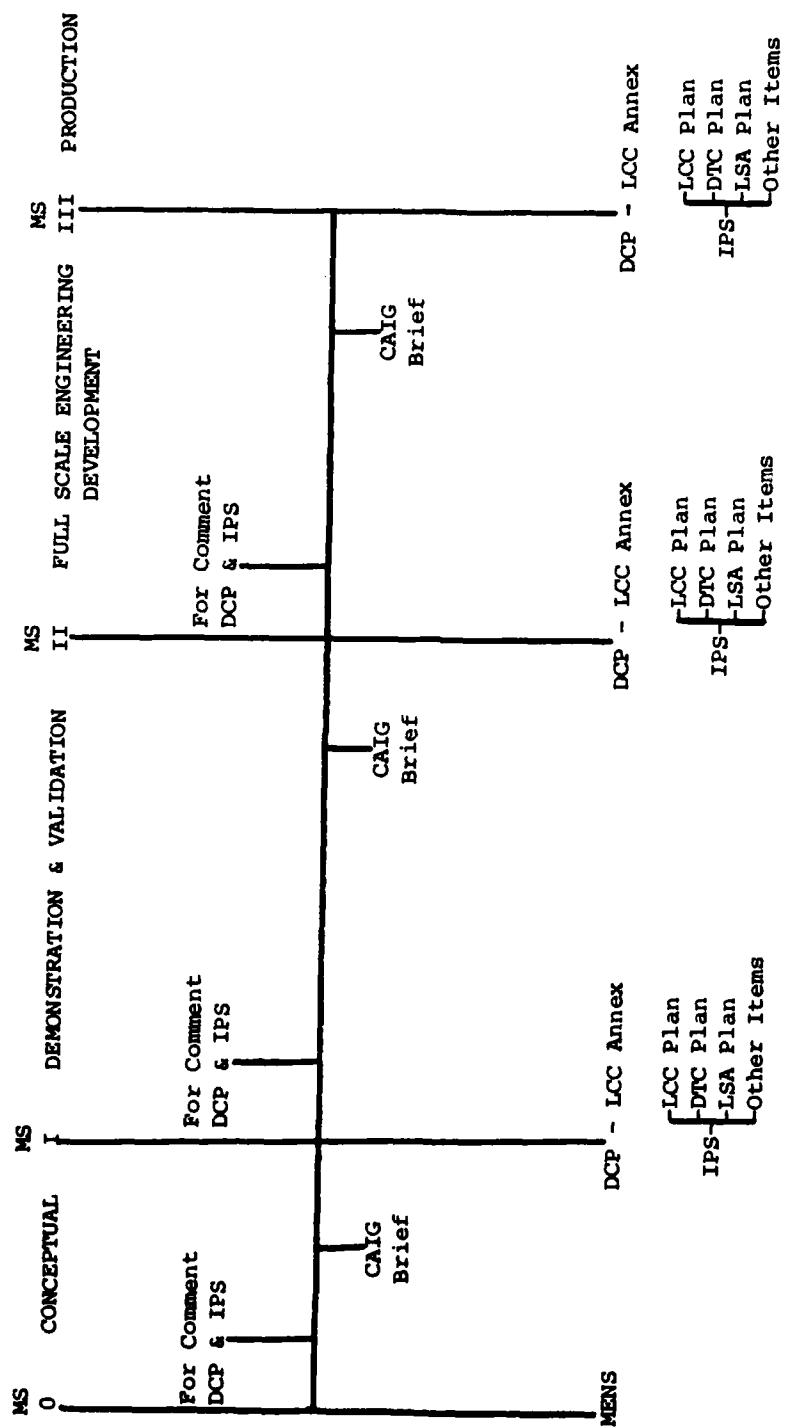


Fig. 3. DOD LCC Requirements

represents the placement of those LCC requirements identified in the previous paragraphs. The requirements listed tend to support the decision-making process of the Secretary of Defense. The DCP and IPS are the two summary documents used by DOD to evaluate the specific acquisition program. As indicated in DODD 5000.2, each document specifies areas to be addressed during the DSARC presentation, of which LCC is one subject. The schedule of prebriefings prior to the DSARC are designed to iron out problem areas between the DOD Staff and the Program Management Office prior to the actual DSARC review. Of primary concern to the working level LCC manager is the presentation to the CAIG, at which the Program Office's cost estimates--especially LCC estimates--will be thoroughly examined. Included at each DSARC presentation are the Design to Cost goals established for the program. For the working level LCC manager, each of the goals established must have been evaluated on an LCC basis with major emphasis on the DTC goal effect on source selection, contract incentives, and use of warranties.

DODD 5000.39, "Acquisition and Management of Integrated Logistic Support for System and Equipment," which describes the concepts of Integrated Logistic Support (ILS) and Logistic Support Analysis (LSA), makes no specific reference to using Life Cycle Costing as a technique of evaluation and therefore is the reason for the absence of a

discussion in the DOD Directives section concerning Integrated Logistics Support and Logistics Support Analysis.

Air Force Documents

Air Force Regulation 800-11, "Life Cycle Cost Management Program," is the regulation that implements DODD 5000.28, "Design-to-Cost." This regulation in its implementing paragraph makes no reference to DODD 5000.1 or DODD 5000.2, yet it states that "This regulation states policy, explains procedures, and assigns responsibilities for implementing life cycle cost management concepts during defense acquisition efforts [27:1]." AFR 800-11 defines life cycle cost in a manner similar to that stated in OMB Circular A-109, but adds,

. . . that for the LCC estimate to be meaningful it must be placed in context with the cost elements included, period of time covered, assumptions and conditions applied, and whether it is intended as a relative comparison or absolute expression of expected cost effects [27:1].

The regulation goes further in defining Design-to-Cost as one technique that controls a product's life cycle cost. AFR 800-1 defines six items that an LCC management program should stress.

1. Identifying factors which have a significant impact on LCC results, and implementing trade studies to reduce this impact.
2. Selecting Design-to-Cost goals to help control LCC.
3. Choosing an acquisition strategy that supports LCC objectives.

4. Selecting sources for development, procurement, or production which offer the best balance between performance and LCC.
5. Establishing contract commitments to help control LCC.
6. Conducting follow-on efforts for the purpose of involving LCC techniques [27:2].

The regulation goes on to document that LCC management efforts will be tailored to the individual program and that these efforts will be reflected in the Program Management Plan (PMP) and Acquisition Plan (AP).

According to AFR 800-11, in the Program Management Plan (PMP) (Section 3) and Acquisition Plan (AP) (Item 9), the documentation of a Life Cycle cost program must include:

1. The approach for establishing LCC considerations as an integral part of the program decision making process.
2. Specific tasks and milestones related to LCC management.
3. Planned method of addressing LCC during source selection.
4. Planned method of establishing cost-related design goals.
5. Major tradeoff studies anticipated.
6. Cost estimating, tracking, and verification procedures.
7. Planned contractual techniques to support LCC management objectives [27:2].

These items are really the first requirements that are substantive in nature. The DAR is the document which governs the areas of concern that must be addressed in the Acquisition Plan. In Section One, Part 2100, Life Cycle Cost is addressed in the following manner:

Application of LCC: Discuss how LCC will be considered and indicate reasons why it is not being applied. If appropriate, discuss the cost model to develop LCC estimates [34:p.1-218].

This document is important for it goes to the Secretary of the Air Force and, upon approval, acts as authorization for issuance of the Request for Proposal (RFP). In essence, when the Acquisition Plan is approved, the LCC plan contained therein has been given approval.

Embodied in the two lists just identified from AFR 800-11, the six items for an LCC management program and the six items of documentation for the PMP and AP, is an overall description of the duties and workload of the working level LCC manager. One can find individual items repeated in each list, and appropriately so, since both lists are describing the LCC management approach that the working level LCC manager will utilize during the acquisition of the weapon system. As each DSARC review approaches, the working level LCC manager must restructure the information dictated by these lists into the format specified by the DCP and IPS for presentation at the DSARC review.

AFR 800-11 dictates that within the acquisition process, LCC cost studies and analyses must be performed to document:

1. The selection of the conceptual solution.
2. Choice of operating and logistics support concepts.
3. Choice of cost related design goals.
4. Source selection procedures.
5. Program design tradeoffs.
6. Decisions regarding repair sources and levels, support resource allocations, manpower allocations, basing concepts, and training equipment requirements [27:2].

The items just described are important, for they give the working level LCC manager some idea of the scope of application of LCC as applied to the acquisition process.

In implementing DODD 5000.28, AFR 800-11 dictates that cost related design goals must be established by Milestone 1 in the form of average unit cost for the production version of the product (including recurring and nonrecurring costs), unit operating crew and maintenance manpower requirements, operational reliability and maintainability factors, and selective design controllable factors which will significantly affect the LCC characteristics of the product (27:3). This information is also part of the DCP and IPS.

An AFSC/AFLC Supplement to AFR 800-11 goes into further detail concerning LCC implementation. During development efforts when LCC is to be an element of source selection criteria, the solicitation will require the offerors to address LCC management issues in their proposals. As a minimum, the following issues must be covered:

1. The planned use of cost-related design goals in the contractor's internal management system.
2. Those areas of design proposed for LCC trade studies.
3. LCC methodology to be used in tracking, status assessment, and reporting process.
4. Management emphasis on potentially high cost areas during design and development [26:1].

These items, as well as other criteria, will be covered in the Source Selection Plan. The purpose of this document

is to act as a management plan of action on how the Program Office will attempt to evaluate contractor's proposals. If LCC is to be a factor in the selection of a contractor, the working level LCC manager will have to indicate the methodology in this plan and describe the LCC criteria by which the evaluation will be conducted. An important point is that the LCC criteria identified in this document will have to be further explained in the RFP, so that potential contractors know that LCC is a criteria in source selection.

The supplement to AFR 800-11 identifies various LCC responsibilities that have been assigned to the various divisions of AFSC and AFALD and is a good reference for the working level LCC manager in finding various levels of assistance in his efforts. The supplement has one section which outlines the Program Manager's responsibilities with respect to life cycle costs. Paragraph 5L2 of the supplement tasks the Program Manager to establish a focal point within his SPO organization to act as the central contact for all LCC efforts. This focal point is recommended to be in Program Control, with the following duties:

1. Ensure that inputs to LCC analyses reflect current approved program and budget estimates.
2. Ensure that a current system LCC estimate exists and is based on current force planning, program direction, and fiscal guidance.
3. Ensure that cost-related design goals are established for both system and support system design characteristics.
4. Ensure LCC contracting techniques are applied.
5. Ensure that proposed Engineering Change Proposals (ECP's) are analyzed for LCC impact and that the

results are considered as part of the Configuration Control Board evaluation.

6. Ensure that major LCC issues are subject to contractor or government LCC trade studies.
7. Ensure that LCC estimates presented during program reviews are consistent and compatible with current program baseline and reflect the potential impact of major program design, schedule, performance and price.
8. Ensure LCC related contract administrative tasks are coordinated [26:4].

This supplement is the only document found that establishes the position of an "LCC manager" and outlines the duties of the position. By reading the list, one gets the impression that LCC is an all-encompassing concept stretching across all disciplines within the System Program Office and applying during all phases of the acquisition process. The problem is that no further guidance (or authority) is given to this focal point to facilitate these duties being carried out.

One of the few references to LCC and its potential integration with ILS is mentioned in an ASD supplement to AFR 800-11 when it dictates that LCC management efforts as documented in the AP and PM, will be submitted to the AFALD/AFASD Joint Working Group for review and coordination prior to release of a draft RFP (26:2). The stated purpose of this review is to establish the validity of the LCC management approach as documented in the AP and PMP. The supplement also requires that for Program Assessment Review (PAR) /Command Assessment Review (CAR) presentations the following LCC issues be addressed: LCC Estimate Track,

LCC Estimate Changes, Cost-Related Design Goals, LCC Top
Ten Drivers.

AFR 800-2, "Acquisition Program Management," outlines the acquisition process and the different sections of a Program Management Plan, addresses LCC in Attachment 4, "Precepts of a Program Management Plan." This attachment discusses the tradeoffs of performance and design requirements against effectiveness, risk, and LCC throughout the program, and urges that Logistics Support Analysis (LSA) and LCC techniques be incorporated into the System Engineering Process to ensure early identification of logistics support considerations (21:3).

Air Force regulations and supplements that pertain to LCC fail to mention how LCC should be integrated with other activities of the SPO, i.e., System Engineering, ILS Planning and Logistics Support Analysis. AFR 800-8, "Integrated Logistics Support (ILS) Program," which is the implementing regulation for DODD 5000.39, "Acquisition and Management of Integrated Logistic Support for Systems and Equipment," dictates that LCC management efforts must be documented in the PMP and AP and states that:

1. LCC studies and analyses must be performed to document trade-offs and decisions that significantly impact on LCC results. Decisions regarding repair sources and levels, support resource allocations, and manpower allocations must be considered in light of LCC.
2. Many ILS elements contain factors that have a significant impact on LCC results and are therefore

subject to trade-off studies to evaluate actions that would reduce the impact of such factors.

3. Cost-related design goals must be established on design controllable ILS factors that significantly impact the LCC characteristics of the product.
4. The Logistics Support Analysis Record (LSAR) should provide a single, consistent source of logistics data, used in logistics cost analysis and operating and support cost estimates [25:4].

Further, the regulation states that:

. . . operational reliability, maintainability, and other support data must be made available to defense contractors. During pre and post contract award activity, this information can provide a baseline for support analysis, trade-off studies and LCC analysis [25:5].

This is the only time during the course of the research, that a specific reference was made to the integration of Life Cycle Costing, Integrated Logistics Support, and Logistics Support Analysis. As indicated by the regulation, many elements of ILS can have a profound effect on LCC estimates, yet in AFR 800-11, "Life Cycle Costing," no mention of this cause and effect relationship was found.

The principal document used by the SPO to solicit contractor proposals is the Request for Proposal (RFP). In today's environment, the SPOs are also issuing a draft RFP to solicit contractors' comments. The draft RFP is designed to help iron out the bugs with design concepts and make general comments on specified requirements. The Executive Summary, although not an official part of the RFP, briefly outlines the program and contract strategy to be followed. A potential use of the Executive Summary

is the discussion of special interest subjects of which LCC/Design to Cost could be one. Under Section H, Special Provisions of the RFP (30:4-12), are contained special and unique contract clauses applicable to the offeror's response. In this section, one would find those LCC RFP provisions designed to motivate the offerors to design the system with LCC considerations. In addition, those strategies relating to Design to Cost and Warranties/Guarantees will be identified in this section.

In Section J, "Documents, Exhibits and Other Attachments" (30:4-21), one would find the Statement of Work (SOW), which in major system acquisition is structured according to a Work Breakdown Structure. The SOW will include the requirements for the contractor to establish an LCC Management Plan. The extent of the LCC program, its tracking, reporting, and level of integration are all specified in this section for the upcoming and follow-on phases of the program.

Section L (30:4-44), "Instructions and Conditions, and Notices to Offerors," identifies the logistics scenario and specifies the elements of an LCC model that will be utilized, plus the sources of data to be used.

In Section M, "Evaluation Factors for Award" (30:4-64), one would find a description of the part LCC will play in evaluating the offeror's proposal. in this section, the offeror must be given unambiguous

definitions of the evaluation and selection criteria relating investment cost, schedule, performance, and O&S costs. Criteria concerning LCC estimates and pre- and post-award testing are also located in this section.

Air Force Summary

The description of Life Cycle Costing and its application to major weapon system acquisition is, at best, spread over many Air Force regulations, supplements, and pamphlets. The efforts of the working level LCC manager must be documented in the LCC Management Plan, AP, and SSP during the Conceptual Phase. The transition from plan to actual contractual requirements takes place in the RFP. During subsequent phases, these documents are updated to reflect current program status. Once the program enters the Demonstration and Validation Phase, the working level LCC manager is involved in executing the LCC Management Plan and then becomes an evaluator of the contractor's efforts. The progress of the program, to include the status of LCC efforts, is summarized in the DCP and IPS and presented at the DSARC review. Figure 4 represents the Air Force LCC requirements identified, as well as the DOD requirements, at the highest level of abstraction.

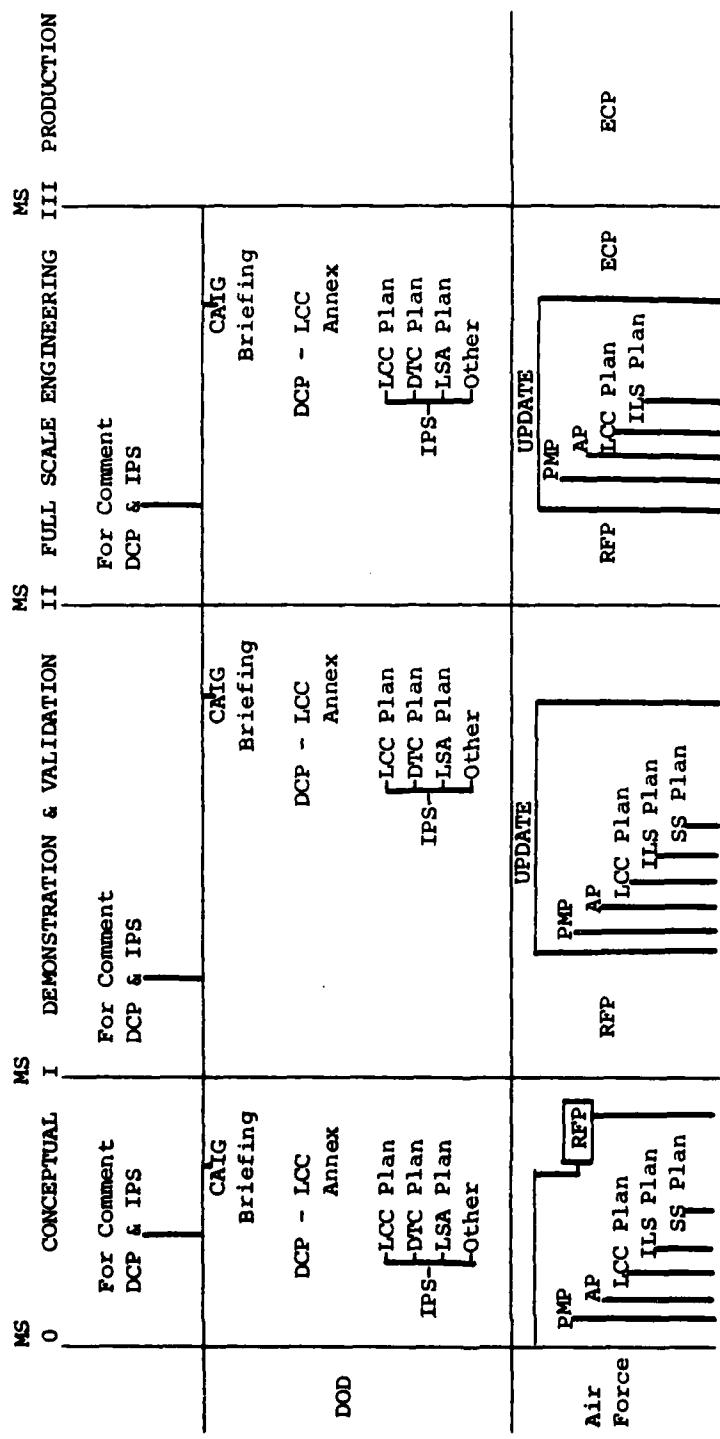


Fig. 4. DOD/USAF LCC Requirements

CHAPTER IV

DATA ANALYSIS

This chapter presents the results of two important avenues of the research effort. These two avenues correspond to research questions 2 and 3:

What procedures and techniques are currently documented to assist the Life Cycle Cost manager in meeting LCC requirements?

What procedures and techniques have been and are being used by Life Cycle Cost managers in the field to design and implement a Life Cycle Cost Program?

The basic emphasis of these questions is to gather information from both literature and field personnel sources concerning procedures and techniques useful to a working level LCC manager. The relevant literature, in this case, included existing "how to" LCC guidance, Air Force regulations, pamphlets, MIL-STDs, and the current Air Force Institute of Technology's LCC textbook. In order to structure the various procedures and techniques discovered in the literature, the time line provided by the phases of the DSARC process was used (Figure 5).

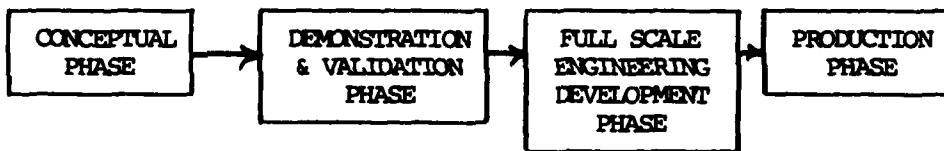


Fig. 5. DSARC Phases

As various procedures were discovered in the literature, they were assigned to the DSARC phase during which they applied.

Techniques, being more specific in nature than the procedures, were conceived of as supporting, or helping to implement a more general procedure. Techniques, therefore, were organized by linking them to the procedure they supported or helped implement. As might be expected, some techniques were assigned to more than one procedure. By this process, a number of procedures and techniques were drawn from the literature and roughly placed into phases of the DSARC process. Several experts in the field of LCC were enlisted to help refine the placement and content of this structure. The resulting organization of LCC procedures and techniques were then incorporated into an interview guide (Appendix A) for the purpose of gathering field knowledge and experience about the procedures and techniques. The researchers saw these interviews as a critical follow-on to the literature search. It was our intent to use the interview target group--working level LCC managers-- to generate additional knowledge about the procedures and techniques, give practical advice, and subjectively judge the worth of the procedures and techniques.

Knowledge about the procedures and techniques was indeed gained, but not in the degree of detail needed by the researchers to make the determination as indicated in

the methodology. The primary problem, to be elaborated on in the final chapter, was the generally low level of experience with the procedures and techniques held by the interview target group.

Method of Presentation

One of the principle objectives of this chapter is to organize the information from both the literature study and interviews into an understandable format, amenable to future expansion and manipulation. The main method to do this, as already mentioned, was to place the identified procedures and associated techniques into the appropriate phases of the DSARC process. In tabular form (Table 4), the procedures and techniques break out in the manner shown. Utilizing the organizing mechanism represented by Table 4, each procedure and technique will be further explained. First, each procedure will be briefly defined. Then every technique will be similarly defined, along with any particular advantages or disadvantages in its use. Also, sources for input data, assistance, or more detailed treatment of the technique will be provided. Finally, at the end of each DSARC phase discussion, the procedures and techniques of that phase will be related to the LCC requirements that necessitate their use.

Before discussing each individual procedure and technique, a treatment of the tool that is used extensively

TABLE 4
PROCEDURES AND TECHNIQUES BY PHASE

Phase	Procedure	Technique
Conceptual	Life Cycle Cost Assessment	Specialist Estimate Specific Analogy Risk Analysis Life Cycle Cost (LCC) Model USAF Cost and Planning Factors
Development of an Acquisition Approach	Cost Benefit Analysis/Cost Effectiveness Analysis	
Life Cycle Cost Implications of Requirements	Life Cycle Cost (LCC) Models Cost Sensitivity Analysis	
Determining the Employment, Support and System Concepts	Level of Repair Analysis/Optimum Repair Level Analysis (ORLA) Logistics Support Analysis (LSA) Maintenance Engineering Analysis (MEA) Failure Mode and Effects Analysis (FMEA) Logistics Performance Factors (LPFs)	
Planning the Use of Life Cycle Cost in the Validation Phase Source Selection	No Specific Technique Required	

TABLE 4--Continued

Phase	Procedure	Technique
Demonstration and Validation	Validation Phase LCC Trade Studies	Cost-Benefit Analysis/Cost Effectiveness Analysis LCC Model
Cost of Ownership Refinement	Engineered Cost Estimating Method Industrial Engineering Standards (IES) Specialist Estimates Specific Analogy USAF Cost and Planning Factors Cost Sensitivity Analysis LCC Model--An Accounting Type Model	
Refinement of the Acquisition Approach	LCC Model Award Fee LCC Verification Test Plan	ORLA LCC Model Failure Modes and Effects Analysis (FMEA)
Full Scale Engineering Development	Detailed System and Support LCC Trade Studies	LCC Model Engineered Cost Estimating Method USAF Cost and Planning Factors Cost Sensitivity Analysis Risk Analysis
Cost of Ownership Refinement		

TABLE 4--Continued

Phase	Procedure	Technique
	Planning the Use of LCC in Contract Source Selection and Negotiation	Learning Curve Analysis LCC Model Pre-Award Testing
	Development of Warranties/ Guarantees	Inspection of Supplies and Correction of Defects (DAR 7-203.5) Warranty of Supplies for Ordinary Equipment and for Complex Supplies Correction of Deficiencies (DAR 7-105.7) Warranty of Technical Data (DAR 7-104.9(o)) Rewarranty of Repaired/Overhauled Equipment Repair/Exchange Agreements Reliability Guarantee Reliability Improvement Warranty (RIW) Mean Time Between Failure - Verification Test (MTBF-VT) Availability Guarantee Logistics Support Cost Guarantee Software Design Commitment LRU Software Configuration Control and Support Agreement
Production	Engineering Change Proposal (ECP) Review and LCC Verification	LCC Model LCC Verification Test Plan

in each phase is in order. This is the LCC model. This section contains a treatment of LCC models that will serve as a reference throughout the phase-by-phase presentation that follows.

LCC Models

Description

An LCC model is a tool that accepts various inputs and processes these inputs to develop an estimate of some or all of a system's life cycle cost. The LCC model may be computer based, on a hand-held calculator, or exist on paper. Conceptually, the LCC models that exist can be broken out into ten categories set out by the ASD/AFLC LCC Management Group. These ten categories are (8:7,8):

1. Cost Factor Model - a model in which each cost element is estimated by multiplying a key weapon system parameter by a factor which is derived as a function of Air Force cost experience on similar weapon systems.
2. Accounting Model - A set of equations which are used to aggregate components of support costs, including costs of manpower and material, to a total or subtotal of life cycle costs.
3. Cost Estimating Relationship (CER) Model - A statistically derived set of equations each of which relates LCC or some portion thereof directly to parameters that describe the design, performance, operation, or logistics environment of a system.
4. Economic Analysis Model - A model characterized by consideration of the time value of money, specific program schedules and the question of investing money in the near future to reduce costs in the more distant future.

5. Logistic Support Cost Simulation Model - A model which uses computer simulation to determine the impact of an aircraft's flying program, basing concept, maintenance plan, and spare and support resource requirements on logistic support cost.
6. Reliability Improvement Cost Model - A set of equations that reflects the costs associated with various increments of improvement in equipment reliability.
7. Level of Repair Analysis Model - A model that, for a given piece of equipment, determines a minimum cost maintenance policy from among a set of policy options that typically include discard at failure, repair at base, and repair at depot.
8. Maintenance Manpower Planning Model - A model that evaluates the cost impact of alternative maintenance manpower requirements or the effects of alternative equipment designs on maintenance manpower requirements.
9. Inventory Management Model - A model that determines, for a given system, a set of spare part stock levels that is optimal in that it minimizes system spares costs or minimizes the Not Mission Capable Supply (NMCS) rate of the system.
10. Warranty Model - A model that assesses the relative costs of having the Government do in-house maintenance versus having this maintenance performed by contractors under warranty.

These are general categories of LCC models. Currently there are a number of specific models that the working level LCC manager should be familiar with. These include:

1. AFLC Logistics Support Cost (LSC) Model. The LSC model is an accounting type model that estimates support cost for early system designs. The model can be used to differentiate among competing designs (16:C-1).

2. Logistics Composite Model (LCOM). LCOM simulates operations and support functions including servicing, "malfunctions, accomplishment of flight-line aircraft maintenance, item repair in intermediate shops, utilization and interaction of maintenance resources, etc. [5:373]." The model can optimize resource levels (including personnel) and "evaluate interaction between maintenance policy, resource availability, and operational effectivenss [5:373]."

3. LCC-2 and LCC-2A Models. These two models are designed to evaluate the cost of an avionics system over its entire useful life. The models are useful for "comparing support concepts (two or three levels of maintenance), performing sensitivity analysis, and identifying cost driving parameters [1:ii]."

4. Modified-Multi-Echelon-Technique-for-Recoverable-Item-Control (MOD-METRIC). This model is designed to support various aspects of provisioning and managing spares inventories. The model computes spare levels for all echelons (base, depot, intermediate) considering backlog and spares investment costs. The model requires a well-defined maintenance concept and repair level analysis (16:C-22).

All models discussed so far are computer-based. In ASD/ACCL a number of LCC models are available that

operate on a programmable calculator. The models include avionics, airframe and software oriented procedures.

Advantages

The LCC model is one of the fundamental tools of a LCC manager. It is useful for a host of things including computing overall cost, viewing the impact of design trade-offs, performing sensitivity analysis, giving the contractor a basis for LCC design, evaluating post-production LCC effectiveness, and performing source selection. A LCC model can be modified to fit specific situations and can serve as the primary tool for evaluating overall LCC effectiveness.

Disadvantages

Once a LCC model has been delivered to a contractor, it is possible to analyze the driving parameters of the model and "game" responses so as to appear very LCC effective. The LCC model must therefore be carefully constructed to reward true LCC-reducing initiatives. A second disadvantage is that some LCC models may contain out-of-date or incorrect assumptions, rates and equations. Modifying or correcting a large LCC model could be a task too long and complex for the time available in the early phase of a weapon acquisition.

Information Sources

The primary sources of assistance for selecting, modifying and running an LCC model are in ASD/ACCL and AFALD/XR. Various models already mentioned also have specific sources of information: LCC Model--The User's Handbook can be obtained from AFLC/AQMEL (16:C-1). LCOM Simulation Software User's Guide is available from AFMSMET at Wright-Patterson AFB, Ohio. LCC-2 and LCC-2A user documentation is available from ASD/ACCL. MOD-METRIC user information is available from AFLC Pamphlet 57-13 (16:C-22).

Conceptual Phase

During the Conceptual Phase, the SPO is attempting to define solutions to the need identified in the Mission Element Needs Statement (MENS). As the title of the phase indicates, the SPO will be working with concepts, the more detailed analysis being left to later stages in the acquisition process.

It is within this environment, requiring broad range and flexible analysis, that the following procedures and techniques are designed to be used.

LCC Assessment

This procedure refers to the overall activity required to generate and track a life cycle cost estimate for a weapon system or its components. This cost includes

the elements of "development, acquisition, operation and support, and disposal [26]."

There are five different techniques that may be used to support the LCC assessment procedure. They are as follows:

Specialist Estimate.

Description. The specialist estimate is a cost estimate obtained from anyone who has expertise or technical knowledge related to the cost of the item being evaluated (16:7-3).

Advantages. The specialist estimate is easily obtained and relatively inexpensive. The specialist estimate may allow costing where state of the art technology is being pushed. It allows costing with relatively little data, and may serve as a check against other more rigorous methods (16:7-3). Essentially, it is the application of common sense, judgement, and/or informed opinion to a relatively ill-defined problem.

Disadvantages. This method allows little control over the derivation of the estimate. It may be difficult to locate experts competent in the necessary area (16:7-3).

Information Sources. The most accessible experts will be cost analysts, engineers, and logisticians in the program in question who have previous experience with a similar item. Other experts might be identified through their connection to a particular item in the AFALD/PT

Lessons Learned Data Bank (16:7-3). Further information on this technique may be found in AFSC Manual 173-1 and the LCC QMT 353 Textbook from the Air Force Institute of Technology (AFIT).

Specific Analogy.

Description. The Specific Analogy method uses the known cost of a previous item to estimate the cost of a similar item of interest. The manner in which the target item is similar or different from the previous item is taken into consideration (19:7.5).

Advantages. The advantages to this method include speed, economy, and relative simplicity (19:7.5).

Disadvantages. The drawbacks include the confounding effect of rapid advances in technology and differences in contractor efficiency.

Information Sources. Current data can be found in AFALD Pamphlet 800-4. A most promising new source of analogy data is scheduled to become available in the near future. This is the Visibility and Management of Operating and Support Costs, System II (VAMOSC II) located at AFLC/LO (Appendix B). Another source is the Product Performance Feedback System (PPFS) in AFALD/PTA. Further information on the technique in general may be found in AFSCM 173-1.

Risk Analysis.

Description. In preparing an estimate of system cost, the analyst is faced with the risk that unforeseen "economic, technical, and program factors" will change the cost of the actual system (16:4-6). The technique for dealing with this uncertainty is risk analysis.

Advantages. Risk analysis gives decision makers some idea of accuracy of the derived cost figures.

Disadvantages. Reliable early cost information is especially important to logistics planners. However, risk analysis performed early in the life of a new system will only be able to return a very broad cost range in which the true cost might be.

Information Sources. AFSCM 173-1 has a good treatment of Risk Analysis. Additional references include: for simulation risk analysis, RAND RM-4854-PR, "Monte Carlo Techniques." For other techniques, a RAND report prepared for the Office of the Secretary of Defense, "Military Equipment Cost Analysis," 1971, is a good reference.

Life Cycle Cost (LCC) Model--A Cost Estimating Relationship (CER) /Parametric Model.

Description. The basic idea behind this technique is that the cost of a system can be predicted by various characteristics or "parameters." For instance, it might be known that there is a statistical relationship

between the cost of fighter aircraft and the parameters of weight of the aircraft, speed, and thrust. If data is available on previous fighter aircraft for cost versus weight, speed and thrust, the use of regression and curve fitting techniques might allow prediction of the cost of future fighter aircraft from a gross weight/speed/thrust description of that new aircraft (16:5-6; 15:7-6).

Advantages. The advantages with this technique include low expense and speed. Since it is based on gross parameters, it can be employed early in a program to judge tradeoffs and make program decisions (16:5-7).

Disadvantages. The drawbacks to this technique center around its inapplicability to new systems that incorporate radically new technology, as indicated by the following excerpt from a current LCC Analysis Guide.

The statistical relationships used are derived from experience, and that experience must be relevant to the new system. Hence, the new system must fit into an existing family of systems or be similar enough to such a family to justify use of the CER method, perhaps with some adjustment. The Cost Estimating Relationship method consequently may not produce reliable results for a system which depends heavily on new technology or incorporates drastically different design features [16:5-7].

Information Sources. Additional information can be obtained from AFSCM 173-1, Life Cycle Cost Analysis Guide, p. 5-6 (from ASD/ACCL), and a RAND Study, "Military Equipment Cost Analysis," 1971. In the near future, input data may be accessible from VAMOSC II in AFLC/LO and the

Product Performance Feedback System (PPFS) in AFALD/PTA (13). Currently available input data sources include the AFLC systems D056 and K051. In addition, civilian contractors often maintain historical CER information on earlier, analogous systems.

USAF Cost and Planning Factors.

Description. This is not an actual technique, but a broad collection of factors to use in cost estimating. The factors deal with such categories as pay, fuel, maintenance, aircrew composition, spares, munitions, depot, etc. (32:i).

Advantages. The planning factors are easy to use and are standardized across the USAF.

Disadvantages. A specific rate given by the USAF Cost and Planning Factors pamphlet may be very different from the actual rate the particular system being costed will display. The difference could be attributed to unique environments, missions, etc.

Information Sources. The only official source for the Cost and Planning Factors is the USAF Cost and Planning Factor pamphlet.

Development of an Acquisition Approach

This second procedure refers to the overall activity of planning the acquisition strategy. A technique

that supports this general procedure is as follows
(16:4-9).

Cost-Benefit Analysis/Cost-Effectiveness Analysis.

Description. Cost-Benefit Analysis is a systematic approach to selecting between competing allocations of resources.

It requires the definition of objectives, the identification of alternative ways of achieving each objective, and the identification, for each objective, of that alternative which yields the required level of benefits at the lowest cost [19:23].

Advantages. The advantage to using this method is that it systematically considers alternate feasible direction for system development, utilizing cost as a primary factor.

Disadvantages. The danger with a technique using as its primary rule "lowest cost" is that necessary operational capability may be compromised. Another danger is that reduction in short term costs may be chosen at the expense of creating long term costs. For example, an avionics cooling system constructed of inexpensive tin may be good for reducing short run costs, but cause greater long term maintenance costs as frequent leaks and replacements occur.

Information Sources. A discussion of this technique is contained in DODI 7041.3 and AFR 178-1. Staff assistance from AFALD/XRP may also prove helpful.

Life Cycle Cost Implications of Requirements

This procedure aims at providing the working level LCC manager with insight into the cost implications of various requirements the evolving weapon system must meet.

The primary objectives of this analysis are: (1) to identify those aspects of the requirements which drive life cycle costs; (2) to detect significant cost differences among performance level alternatives; (3) to identify major uncertainties with respect to requirements, capabilities and costs; and (4) to use this information to arrive at a set of requirements which attempt to properly balance cost, performance and schedule constraints [16:4-1].

Techniques that support this general procedure include:

LCC Models. This is usually a Cost Estimating Relationship (CER) model (see previous discussion, page 44).

Cost Sensitivity Analysis.

Description. Cost sensitivity analysis refers to observing how changing various assumptions, factors, inputs or other variables will "affect resource requirements including cost [15:3-21]." For example, in evaluating a contractor's proposal, it is noted that a particular LRU is projected to have a MTBF of 1000 hours. By varying this MTBF figure in a LCC model (or other cost estimating device) we can evaluate how deviations from this MTBF could affect manpower requirements, spares, and other elements of cost.

Advantages. Cost sensitivity analysis can help identify:

1. Elements that are cost sensitive.
2. Areas in which system performance can be upgraded without increasing program cost substantially.
3. Areas in which design research is needed to surmount substantial cost obstacles to achieving higher program performance.
4. The total cost impact of uncertainties in the considerations of a program [15:3-12].

This type of analysis may be conducted at varying levels of detail during any phase of system acquisition.

Disadvantages. A parameter identified as being sensitive may in fact be artificially driven because of an inaccurate underlying assumption or factor. Cost sensitivity analysis is only accurate to the extent that the underlying equations capture reality.

Information Sources. A discussion of Cost Sensitivity Analysis is contained in the LCC Procurement Guide (from ASD/ACCL). Most computer-based LCC models will allow this type of analysis by varying inputs or internal model assumptions and observing the results.

Determining the Employment, Support and System Concepts

This procedure is to "support decisions concerning alternative employment concepts, support concepts, and system design and performance characteristics (including reliability and maintainability) [16:4-3].". Techniques to support this procedure include:

Level of Repair Analysis/Optimum Repair Level Analysis (ORLA).

Description. Level of Repair Analysis is a term assigned to an analysis technique which establishes (1) whether or not an item should be repaired; (2) at what maintenance level it should be repaired, i.e., organizational, intermediate or depot; or (3) if the item should be discarded [16:5-15].

Advantages. ORLA gives structure to the level of repair decision that involves numerous costs: material, transportation, manpower, etc. (29:1).

Disadvantages. ORLA will be able to identify the most economical level of repair, but the level selected may not be the best when wartime mobility and transportation vulnerability are considered.

Information Sources. Repair Level Analysis is treated in AFLCM/AFSCM 800-4 and the LCC Analysis Guide (16:5-15).

Logistics Support Analysis (LSA).

Description. LSA is the process of analyzing a given or assumed system/equipment design configuration to determine specific logistics support requirements in terms of: maintenance functions/tasks, repair skills and quantity, support and test equipment, facility requirements, technical data requirements, transportability, handling/packaging requirements, etc. [16:5-14].

Advantages. LSA provides the analysis needed for developing a support system and philosophy while the weapon system is being developed. LSA therefore provides the basis for early supportability design.

Disadvantages. The responsibility for supporting a weapon system falls on the Air Force Logistics Command (AFLC), while LSA is being performed in a predominantly AFSC/ASD environment. Conflicts born of differing command responsibilities may tend to impede LSA integration into the system development process.

Information Sources. LSA is discussed in MIL-STD 1388. Additional significant references include MIL-STD 881, AFSCP/AFLCP 800-34 (Ch. 10), and AFLCR/AFSCR 800-36 (30:2-14). The Logistics Support Analysis Record (LSAR) is the repository for LSA data. The Product Performance Feedback System (PPFS) in AFALD/PTA will automate data from the LSAR and make it available for analysis and manipulation. The system will be tested in the upcoming C-X or Long Range Combat Aircraft (LRCA) procurement (13).

Maintenance Engineering Analysis (MEA).

Description. MEA is an interface between the system engineering effort and maintenance requirements (16:5-14).

For instance,

Maintenance requirements (failure modes and frequency) are derived from reliability/design analysis and are used in turn to determine repair procedures, task time, manhours, tools and skills [16:5-14].

Advantages. MEA is crucial to LCC analysis in that it provides input variables such as failure rates, time to repair, and skill levels.

Disadvantages. MEA data may not be in the exact form needed for LCC analysis and will have to be modified or converted to appropriate forms.

Information Sources. During this phase of the program the most accessible sources of MEA data are reports generated by the contractor or internal System Program Office (SPO) reports from reliability and logistics engineers responsible for MEA. In the near future the PPFS in AFALD/PTA will have MEA data available in automated form.

Failure Mode and Effects Analysis (FMEA).

Description. FMEA is a technique that attempts to improve the design of any particular unit.

The FMEA looks at each part within the unit and determines what happens if the part fails. In this manner, one can design to eliminate potential catastrophic failure modes and also eliminate extra parts or ones that are used to achieve more performance than is necessary [16:5-14].

Advantages. FMEA forces one to consider the support, redundancy, and cost effects of different equipment failures before the system is in the field.

Disadvantages. Failure patterns in the field may differ from that anticipated due to unforeseen missions, environment or modifications. Also, as evidenced by today's force structure, weapon systems may be called upon to perform for more years than originally planned. Operating a system in its wear-out phase leads to different types of failure patterns.

Information Sources. The most accessible data for FMEA can be obtained from reliability testing and maintenance engineering analysis documentation reported by the contractor (such as the Logistics Support Analysis Record (LSAR)).

Logistics Performance Factors (LPFs).

Description. Logistics Performance Factors (LPFs) are standard factors that quantify logistics performance. The factors include availability, reliability, and maintainability.

Advantages. Logistics Performance Factors facilitate communication between logistics planners and technical design engineers. They allow comparison of system logistics performance with that of previous or parallel systems. Finally, they provide tools for tradeoff analysis and design changes.

Disadvantages. Logistics Performance Factors (LPFs) measured by laboratory tests may differ substantially from the parameters actually experienced in the field (16:5-4 through 5-19).

Information Sources. AFLCP 800-3 contains standard LPFs along with historical values. In the near future, this type of data will be automated and available from the VAMOSC II in AFLC/LO. Additional references include MIL-STD 473, AFRs 80-5 and 80-14 (16:5-19).

Planning the Use of Life Cycle
Cost in the Demonstration &
Validation Phase Source
Selection

The objectives of this analysis are (1) to state the importance of life cycle cost relative to other program objectives; (2) to clearly state what validation phase contractors are to do to reduce life cycle costs; and (3) to develop Request for Proposal (RFP) guidance and source selection criteria that encourage the contractor to evolve low life cycle cost system or equipment design options during the validation phase [16:4-11].

There are no specific techniques to help implement this procedure, but activities that should take place to implement the procedure include:

- a. Develop an overall plan to search for life cycle cost reduction opportunities.
- b. Determine how the contractor should present life cycle cost reduction opportunities and supporting information.
- c. Determine how information to be provided by (b) will be evaluated.
- d. Determine the relative importance of reliability and maintainability requirements and goals.
- e. Determine how the contractor should present reliability and maintainability trade-offs and supporting information.
- f. Determine how information provided by (e) will be evaluated.
- g. Determine criteria for source selection, and develop source selection evaluation standards.
- h. Develop special provisions covering life cycle cost and design to cost to be included in the Request for Proposal [16:4-12].

Conceptual Phase Summary

The Acquisition Process. During this phase the SPO was attempting to find solutions to the need defined in the MENS. The Program Memorandum Decision (PMD) from Headquarters USAF and AFSC Form 56 established program

objectives and constraints. The Program Manager (PM) established a Program Management Plan (PMP) and an Acquisition Plan (AP) that detailed the SPO's plans for developing and acquiring the weapon system. Finally, a Request for Proposal (RFP) was written and given to prospective contractors to solicit ideas and designs for a weapon system that could fulfill the need defined in the MENS.

The Weapon System. The weapon system during this phase does not exist as hardware or even a detailed drawing. The main thrust in this phase is to generally define a weapon system capable of fulfilling the need stated in the MENS, without regard to specific hardware. This generally defined weapon system is termed the "functional baseline" (19:3.9).

The Working Level LCC Manager. During the Conceptual Phase the working level LCC manager was involved in a number of important activities: assessing the LCC of prospective weapon systems, helping to develop the acquisition approach, providing cost analysis on specific weapon system requirements and performance parameters, assisting in the development of employment and support of the weapon system, and planning the use of LCC in the Validation Phase source selection. The sum total of his efforts were aimed at embedding LCC as a philosophy and design reality in every division during this critical early phase. The

requirements that impacted the working level LCC manager and the procedures that were needed to fulfill these requirements are related in Figure 6.

Demonstration and Validation Phase

With the contractors' proposals evaluated, and further guidance received following the DSARC review, the SPO now has a functional baseline established. The objective of this phase is to develop this baseline into a detailed System Specification. Since the working level LCC manager has a more refined baseline to work with during this phase, LCC analysis can become more detailed in nature.

Validation Phase LCC Trade Studies

During the Validation Phase of a weapon system acquisition, trade studies are particularly important.

The principal objectives of these LCC trade studies are:

(1) to assure that life cycle costs are logically and consistently considered in continuing equipment and support system design iterations; (2) to promote innovation among competing vendors to offer lower ownership cost designs; and (3) to continually assess the life cycle cost implication of requirements [16:4-13].

The two techniques most useful to supporting this procedure have been discussed in detail in the previous Conceptual Phase. The techniques are:

Cost-Benefit Analysis/Cost Effectiveness Analysis

(page 54).

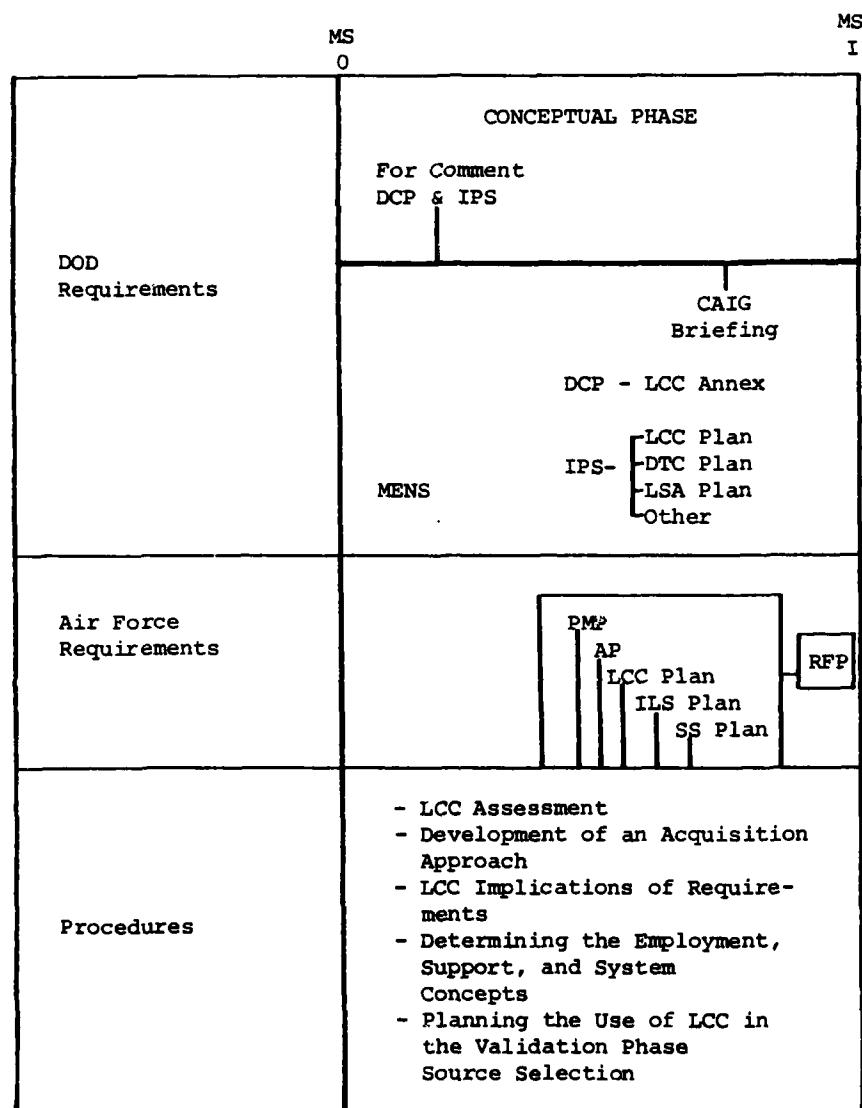


Fig. 6. Conceptual Phase Requirements and Procedures

LCC Model (page 44). The LCC model used in the Validation Phase may still be the CER type model used in the Conceptual Phase. As more detailed engineering data becomes available in the Validation Phase, the various types of LCC models that can perform a "bottoms up," or accounting type of cost estimate should be employed.

Cost of Ownership Refinement

The purpose of this procedure is to construct more accurate and current ownership cost estimates in light of the more refined level of Validation Phase engineering design data (16:4-26). Cost of ownership estimates are especially important tools to logistics personnel during this phase for their utility in affecting the overall system design for supportability. During this phase, the overall weapon system design and its supportability characteristics will be almost totally finalized. Various techniques that support this procedure include:

Engineered Cost Estimating Method.

Description. The Engineered Cost Estimating method is a detailed estimating approach that can be applied to a system that has fairly well established definition to its subsystems and components. The manner in which the estimate is developed is described in The Life Cycle Cost Analysis Guide:

Total system cost is broken out into many elements, consisting of breakdown into finer details of hardware, functions, procedures, etc. The elements are related through cost equations which reflect in detail the way the elements interact when the system is developed, produced, operated and supported [16:5-7].

The equations that are formed by this type of breakdown presumably reflect the real life system so well that they can be called "engineered" equations (16:5-7). Using these equations should then give a good estimate of the total cost of the system.

Advantages. Obvious advantages with this method of estimation come from the refined level of detail used in making the estimate. The estimate may be more accurate than CERs, allow trade studies on components/subsystems, and "permit study of cost differences among competing functional proposals (for production, development, inspections, support procedures, etc.) [16:5-8]."

Disadvantages. Important drawbacks to this method include the cost and time the method demands. A second disadvantage is that the method cannot be employed until the system has been developed to a fairly high level of detail. "By that time, certain prior decisions have already eliminated some of the alternatives which now appear more attractive [16:5-8]."

Information Sources. Input data for this method will be obtained from the contractor. It would be especially helpful if provisions were made to have the

data for the engineered estimate placed by the contractor into an automated data base as the design of the system progresses. This principle is being applied by the PPFS in AFALD/PTA by inputting the Logistic Support Analysis Record (LSAR) into an automated system. The Strategic Systems SPO has experience with a similar initiative (13). General information on the technique itself can be found in AFSCM 173-1, Cost Estimating Procedures.

Industrial Engineering Standards (IES).

Description. IES gives the cost analyst, in either dollars or man-hours, a standard estimate of tasks that must be performed in manufacturing a given subcomponent or piece of equipment (24:4-2).

Advantages. IES allows rapid estimating of the cost/manpower required for fairly standard manufacturing tasks by the contractor. It allows some standard of comparison between competing contractor proposals (24:4-2).

Disadvantages. The standard cost/manpower estimates given may greatly differ from those the contractors actually experience. IES represents "average" performance. If more refined estimates are needed, for example in preparing for contract pricing negotiations, actual measurements inside the contractor's production facility should be made. Also, the estimates derived should be analyzed in

conjunction with the anticipated production "learning curve" (24:4-2).

Information Sources. Further information concerning IES can be found in AFM 173-1.

The remaining techniques in support of this procedure have already been addressed in the Conceptual Phase. These techniques include:

Specialist Estimates (page 49).

Specific Analogy (page 50).

USAF Cost and Planning Factors (page 53).

Cost Sensitivity Analysis (page 55).

LCC Model--An Accounting Type (page 44).

Refinement of the Acquisition Approach

The objectives of this procedure are to update and expand the development procurement plans initiated in the Conceptual Phase, develop LCC related contractual provisions for the Full Scale Engineering Development contract, and reduce overall LCC of the system being developed (16:4-19).

Techniques that support this procedure include:

LCC Model.

Description. See page 44.

Advantages. An LCC model is an effective tool for identifying the main cost drivers in the weapon system. Once the government has identified these cost drivers, a

contractual technique can be used to motivate the contractor to hold the costs down on these driving elements.

Disadvantages. It is possible for a contractor to analyze the underlying equations of an LCC model and "game" responses so as to appear very LCC effective. The LCC model chosen must be constructed to reward true LCC-reducing initiatives.

Information Sources. See page 48.

Award Fee.

Description. The award fee is a contract technique that sets money aside to be awarded to the contractor upon an essentially subjective evaluation by the government of "how well the contractor has performed with respect to life cycle cost [15:4-10]."

Advantages. The award fee is a flexible contract tool that can be used to draw the contractor's attention to some aspect of the system design where substantial LCC savings can be obtained.

Disadvantages. The amount of money provided to the contractor via an award fee has tended to be small in comparison to the overall contract fee. In this situation an award fee alone will not be enough to force LCC considerations into the design.

Information Sources. Information on the use of the award fee can be found in the Life Cycle Cost

Procurement Guide (from ASD/ACCL). Also staff members of AFALD/PP, Deputy for Procurement and Production, will be able to give assistance in designing the contract language and using the technique for maximum effectiveness.

LCC Verification Test Plan.

Description. The LCC Verification Test Plan is a technique that reduces overall LCC of a weapon system by binding the contractor to negotiated LCC performance. LCC performance will be measured based on data gathered from the future operational system. From these actual measures he (the contractor) will either be rewarded for exceptional performance or penalized by having to correct or compensate for shortfalls. For example, in a thesis by Davis and Wysowski the F-16 SPO's use of a LCC Verification Test Plan was presented (9:7-11). In the F-16 SPO the Logistics Support Cost (LSC) Model was used to identify and rank high cost driving system subcomponents termed First Line Units (FLUs), according to cost impact. The highest cost driving FLUs together comprised a Control FLU Target Logistics Support Cost (TLSC) that was guaranteed by the contractor through a Logistics Supportability Cost Commitment (LSCC). When the F-16 becomes operational, at a certain level of system maturity, actual data will be gathered to compute a Measured Logistics Support Cost (MLSC). If this measurement shows that the Control FLU

MLSC is less than the Control FLU TLSC the contractor may earn up to a \$2 million award fee. On the other hand, if the Control FLU MLSC is more than 1.25 times greater than the TLSC, the contractor will perform a Correction of Deficiency (COD) by providing spares or engineering changes at no cost. For Non-control FLUs, the contractor can earn an additional award fee up to \$6.4 million for delivering a MLSC less than the predicted TLSC. Control FLUs are covered by a Reliability Improvement Warranty (RIW), a technique explained on page 87. This entire process is depicted in Figure 7.

Advantages. A Life Cycle Cost Verification Test Plan provides the means for "feeding back" how effective efforts to reduce LCC have been. It forces the contractor to think ahead in his design efforts, knowing that difficult-to-support designs will cost him at a future date.

Disadvantages. A LCC Verification Test Plan must be written and negotiated on assumptions about the configuration, environment, mission, and maturity of the weapon system at a future date. There is actually little chance that the actual parameters surrounding the weapon system will match those anticipated. This means as a minimum, renegotiation, and at the worst an invalidation of the data for feedback purposes.

Information Sources. A discussion on what must be included in a LCC test plan is in the LCC Analysis

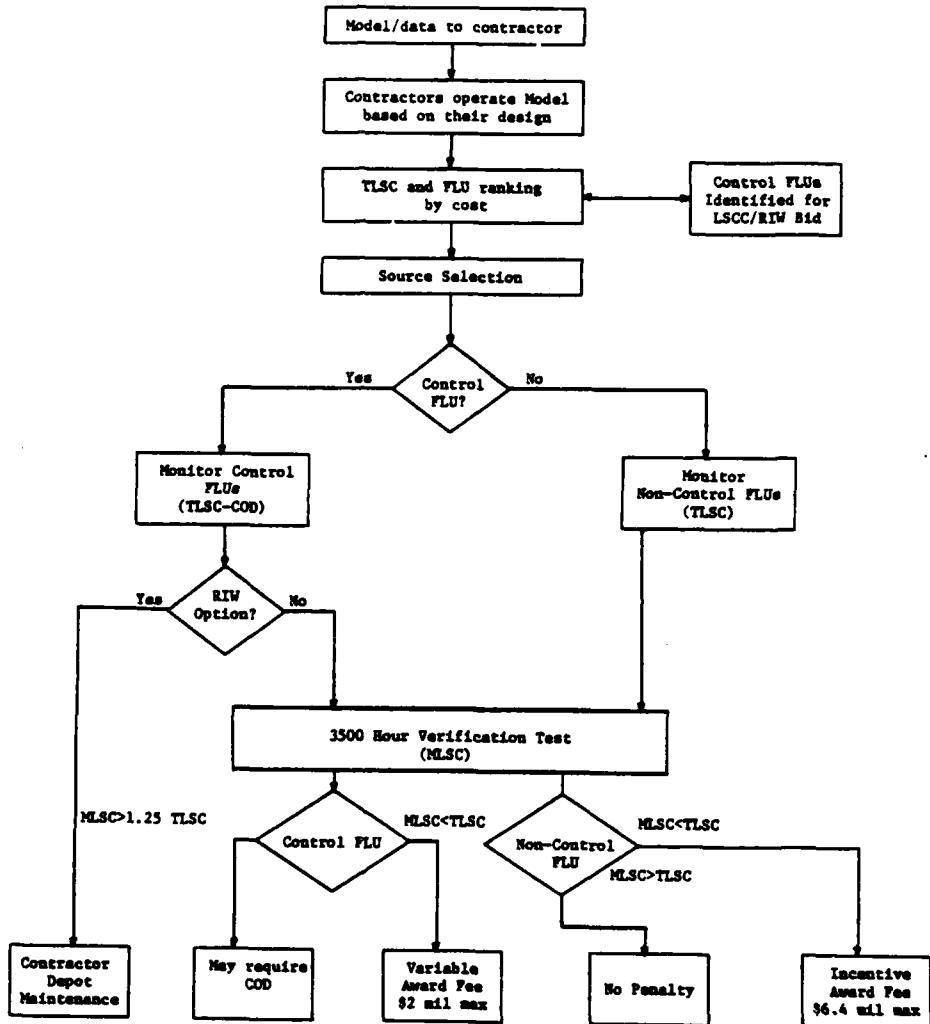


Fig. 7. ACP/F-16 LSC Model Application
(Contractual Commitments)

[9:11]

Guide (16:4-22) available from the LCC Management Group (ASD/ACCL). In addition, the F-16 SPO has spent considerable time and effort in the development of an extensive LCC test plan.

Demonstration and Validation Phase Summary

The Acquisition Process. The Demonstration and Validation Phase began with a favorable Milestone One decision and had as its goal to validate the program characteristics of cost, performance, and schedule. During this phase extensive technical analysis, equipment development, and testing takes place in order to build an "allocated baseline" of realistic system, subsystem and configuration item performance requirements. Competition among contractors for technical innovation was encouraged, especially if it appeared economically impossible to carry more than one contractor into Full Scale Engineering Development (19:3.9).

The Weapon System. During the Demonstration and Validation Phase actual hardware assumed a much greater role. Mockups of critical subsystems, models and prototypes were used to test engineering concepts and reduce technical risk. Cost data from actual system fabrication was therefore available in limited quantities.

The Working Level LCC Manager. With the increased emphasis on actual hardware, the working level LCC manager became more active in the Systems Engineering interface, hopefully influencing design decisions for LCC effectiveness. To do this, the LCC manager conducted trade studies and continually refined the estimate of the weapon system's LCC using parametrics, analogy and for the first time, "Engineered Cost Estimating." During this phase the working level LCC manager updated the LCC Management Plan for input into different sections of the new Request for Proposal (RFP), helped design a LCC Verification Test Plan, developed guidance for source selection, and refined the LCC sections of the Acquisition Plan (AP) and the Program Management Plan (PMP). The overall emphasis of the working level LCC manager's effort was to continue to impart LCC as a philosophy to the SPO and contractors, while at the same time providing more detailed LCC analysis to influence system design.

The requirements that impacted the working level LCC manager and the procedures that were needed to fulfill these requirements are related in Figure 8.

Full Scale Engineering Development Phase

With the completion of the Demonstration and Validation Phase a System Specification has been approved. For the working level LCC manager, this phase is the last

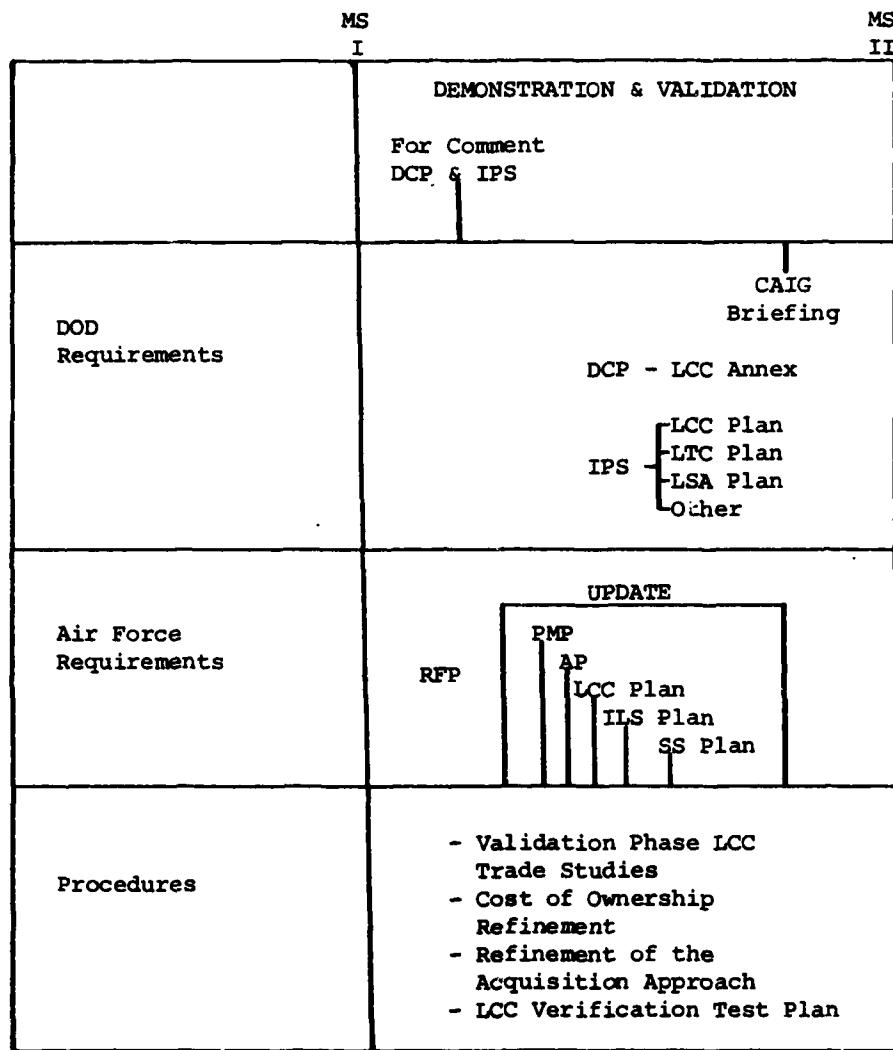


Fig. 8. Demonstration and Validation Phase Requirements and Procedures

chance to have a substantial effect on the overall cost of the weapon system, prior to production. During this phase a Part I and Part II Specification will be developed detailing each system and subsystem; therefore, the procedures and techniques utilized during this phase must reflect a high level of detail. Also, during this phase the Source Selection criteria and use of warranties and guarantees must be finalized.

Detailed System and Support LCC
Design Trade Studies

The primary objectives of this analysis are: to assure (1) that detail design decisions, many of which significantly affect system reliability and maintainability, are arrived at only after proper consideration of life cycle costs; (2) that important life cycle cost design trade study issues surfaced during the full scale development source selection are properly addressed and the results reflected into the production design; and (3) that, as long as system and support design activities continue, life cycle costs are considered in arriving at design decisions [16:4-24].

The techniques most useful for supporting this procedure have already been described in detail in previous sections. The important consideration in using these techniques in this phase, however, is that input data is available in much greater detail (failure rates, design parameters, etc.). The techniques useful here are:

Level of Repair/Optimum Repair Level Analysis
(page 57).

LCC Model. Preferably a detailed accounting type model (page 44).

Failure Modes and Effects Analysis (page 59).

Cost of Ownership Refinement

The purpose of this procedure is to refine previous cost of ownership estimates by the use of more detailed Full Scale Engineering Development (FSED) data. Techniques to support this procedure have been described in a previous section. These techniques operating on more precise FSED input data should output a narrow range of predicted ownership costs having a higher probability of capturing actual ownership costs. Techniques to support this procedure include:

LCC Model (Accounting) (page 94).

Engineered Cost Estimating Method (page 65).

USAF Cost and Planning Factors (page 53).

Cost Sensitivity Analysis (page 55).

Risk Analysis (page 51).

Planning the Use of LCC in Source Selection and Negotiation

The LCC manager has been in continuous dialogue with the contractor through various channels concerning LCC considerations in the proposed system. Source selection time, however, calls for formalizing all LCC goals and stipulation, in order to translate them into contract

language. In order to do this, the LCC manager must work with the contracting and negotiation team to develop:

(1) clear guidance on the importance of life cycle costs and continued consideration thereof; (2) data and guidance on how to estimate and substantiate the life cycle costs of the designs being proposed; (3) an understanding of the role of life cycle cost estimates and bidders' plans for further life cycle cost reduction actions in source selection evaluation; and (4) a full and clear understanding of the planned use of any submitted life cycle cost data with respect to incentive, warranty or other contract provisions [16:4-30].

Techniques to support this overall procedure include:

Learning Curve Analysis.

Description. Learning curve analysis is based on the well known phenomenon that individuals and working groups engaging in repetitive tasks (such as in aerospace manufacturing) exhibit a rate of improvement (speed, accuracy, coordination) in those tasks (19:7-13). The rate of improvement can be observed and fit to a mathematical model or "learning curve" so that the manpower requirement and cost for future units or lots of production can be predicted.

Advantages. Much historical data has been collected on aerospace learning curve phenomenon and the rate of "learning" for system production can be predicted with fair accuracy. This gives government negotiators a strong position from which to keep contract pricing in line with the decreasing manpower and cost the contractor will experience from "learning."

Disadvantages. Radically new technology, changes or breaks in the production schedule, and system modifications can distort or even reverse the learning curve. It is important to compare projected learning with actual measured data and analyze the reasons for difference in the two.

Information Sources. The RAND Corporation published a cost estimating guidebook, "Military Equipment Cost Analysis," 1971, that includes an excellent chapter on learning curve analysis.

A thesis by Allen and Farr, "An Investigation of the Effects of Production Rate Variation on Direct Labor Requirements for Missile Production Programs," is a very fine practical summarization of much recent work in learning curve applications. In the thesis, Allen and Farr review the work of ten previous research efforts in the area of production rates and the associated learning effect (3:8-19). Of practical significance, the authors present a computer-based production rate learning curve model called "PRODRATE" in the appendix to the thesis. The PRODRATE program is presented with all control cards and instructions necessary to use the model for learning curve analysis (3:106-144).

LCC Model.

Description. See page 44.

Advantages. In preparing for negotiation and source selection the LCC model is used for identifying significant cost drivers and performing sensitivity analysis. The LCC model can also be used in source selection and negotiation to aid in developing contract clauses and evaluating competing proposals. Each contractor must be provided with the LCC model to be used in source selection early enough to understand the weight various aspects of his LCC proposal will carry. The LCC model used in source selection should be carefully tailored so as to focus attention on elements that most significantly impact overall life cycle cost.

Disadvantages. A LCC model delivered to contractors for use in preparing their LCC estimates must be carefully designed to reward true LCC reducing initiatives. It may be possible for a contractor to analyze the driving equations underlying the LCC model in order to "game" a response that only appears to be LCC effective.

Information Sources. The best sources of information on the use of LCC models in source selection and negotiation are personnel in the LCC Management Group (ASD/ACCL) and AFALD/XR. In addition, two recent theses efforts, one by Bell and Turney and the other by Davis and Wysowski cover the use of LCC models in source selection (4; 9).

Pre-Award Testing.

Description. Pre-Award Testing is a technique that is essential to the source selection and negotiation process. The idea here is that one of the important factors in awarding the winning contract is best overall LCC performance based on measured LCC related performance criteria. Before contract award, tests of pre-selected LCC parameters are conducted on each competing design and compared (16:4-2).

Advantages. If the competing contractors are aware that certain LCC design parameters will be tested and used in the source selection decision, they will be highly motivated to ensure that those parameters receive management attention.

Disadvantages. The government must be extremely careful in choosing the LCC parameters it will measure for source selection. If the parameters are not of a high order, suboptimization may occur and defeat the overall purpose. For example, it might be decided that the Mean Time Between Failure (MTBF) of the radar system is a key LCC parameter. If the contractor succeeds in creating a radar with an outstanding time between failure, but has positioned some of the components so that it takes half a day and several maintenance technicians to isolate and remove a malfunctioned component, the net may be increased support cost.

Instead of using MTBF as the key parameter "Inherent Availability"¹ might be used. Inherent Availability takes both time between failures and the time to correct failures into consideration.

Development of Warranties/Guarantees

This procedure consists of selecting one or more of a number of warranties/guarantees for inclusion in the production contract. The warranties and guarantees are designed to reduce overall cost to the government.

Several recent developments in the warranty/guarantee area should be mentioned. Air Force Systems Command (AFSC) and Air Force Logistics Command (AFLC) have recently published a joint publication, "Product Performance Agreement Guide." The guide presents the obligations of the Air Force and industry, how warranties and guarantees are related to other program efforts, and a broad survey of currently available warranties and guarantees. Information on the guide can be obtained from HQ AFSC/PMP or from ASD/ACCL (2:1-16).

¹ Inherent Availability (A_i) is the probability that a system or equipment, when used under stated conditions in an ideal support environment (i.e., available tools, spares, manpower, etc.) will operate satisfactorily at any point in time [5:6].

$$\text{Mathematically: } A_i = \frac{\text{MTBF}}{\text{MTBF} + \bar{M}_{ct}}$$

where \bar{M}_{ct} = Mean Corrective Maintenance Time, and
MTBF = Mean Time Between Failure.

A second current initiative is to create at Wright-Patterson AFB a "Product Performance Agreement Center." The center will provide technical support to SPO and contractor organizations on the use of various warranties and guarantees. In addition, it will provide feedback data on the effectiveness of the various warranties and guarantees (2:17).

Finally, the LCC Management Group (ASD/ACCL) is developing a "how to guide" for LCC managers, which includes sample contract clauses for warranties and guarantees.

The Product Performance Agreement Guide is available now, and the Product Performance Agreement Center and "how to guide" from ASD/ACCL will be accessible in the near future. These sources, along with the LCC Management Group and ASD Propulsion SPO (who are deeply involved in state-of-the-art warranties) are good sources of further information.

Currently identified warranties and guarantees include:

Inspection of Supplies and Correction of Defects
(DAR 7-203.5).

Description. Before the government accepts a contractor's product it is tested for defects in material or workmanship. Deviations from the negotiated standard are grounds for rejection (2:A3).

Advantages. Easy to administer; Correction of deficiencies is easily accomplished since the Government pays for all work performed by the contractor; The Government is assured that contractor end items comply with contractual requirements to the extent that such can be determined through actual inspection. Correction of defects is funded by the Air Force [2:A3].

Disadvantages. "The Government pays all or a large portion of the cost required to correct deficiencies [2A3]."

Warranty of Supplies for Ordinary Equipment and Complex Supplies (DAR 7-105.7).

Description. This clause extends the contractor's obligation into the post-acceptance period. Defects in equipment discovered in the field are repaired by the contractor (2:A4).

Advantages. "Causes correction of defects discovered after acceptance at no cost or on an incentive shared basis [2:A4]."

Disadvantages. Requires careful tracking of warranted items; may be difficult to administer where maintenance and logistics support is accomplished principally through Air Force organic means. Burden of proof rests with the Government [2:A4].

Correction of Deficiencies (COD) (DAR 7-105.7).

Description. If, at acceptance inspection or within a negotiated time into field use, equipment fails to meet performance critiera, the contractor is responsible

for correction of the problem to include material and labor [2:A5].

Advantages. Allows no cost for firm-fixed price (FFP), but in the case of incentive contracts, shared costs for correction of design deficiencies are allowed up to ceiling. Cost accountability is not required for FFP contracts. Relatively easy to administer since measurement parameters are clearly defined [2:A4].

Disadvantages. "Coverage is limited to design deficiencies. Air Force is responsible for proving that deficiencies are caused by inadequate design [2:A4]."

Warranty of Technical Data (DAR 7-104.9).

Description. In this clause, the contractor warrants that all technical data is "accurate and complete." Usually for a period of up to three years the contractor will correct bad data or, as another option, be obligated to pay a fee to the Air Force. The contractor may also be made liable for technical data related damages (limited to a certain percentage).

Advantages. Allows update of field data as errors are discovered.

Disadvantages. Some "errors" are subjective and difficult to negotiate (2:A6).

Rewarranty of Repaired/Overhauled Equipment.

Description. If the contractor repairs or replaces spare parts as a result of defects, those spares are rewarrantied for the time remaining on the warranty for the

original item, or a specified period of time (to be negotiated) (2:A7).

Advantages. "Correction of deficiencies discovered after acceptance of repair or replacement item [2:A7]."

Disadvantages. Requires careful tracking of warranted items. Precludes the Air Force from accomplishing the correction of deficiencies. Burden of proof of deficiency rests with the Government [2:A7].

Repair/Exchange Agreements.

Description. The contractor here acts as the supplier for the government. The contractor meets Air Force spare needs within required turnaround times, provides for surge requirements, periodically adjusts inventory levels, and sells out his inventory to the government at the conclusion of the contract (2:A8).

Advantages. Reduces Air Force inventory and management requirements. Precludes demand for critical skilled repair personnel. Will be significantly more cost effective than establishing unique Air Force capabilities for items characterized by low volume turnover. Support costs and availability of replacement items will be more predictable and programmable. Extends contractor responsibility for participation to the field performance phase [2:A8].

Disadvantages. "Air Force is directly dependent upon contractor support for potentially critical items. May preclude cost effective utilization of Air Force repair facilities [2:A8]."

Reliability Guarantee.

Description. If between scheduled overhaul times a specific piece of equipment covered under Reliability Guarantee fails, the contractor must overhaul the equipment early at his expense (2:A9).

Advantages. Motivates contractor to provide increased equipment reliability and as a consequence minimizes disruption of operations between scheduled overhauls; Measurement parameters easily defined. Provides an additional opportunity to learn more about field performance of products. Provides an opportunity for increased profit [2:A9].

Disadvantages. Requires tracking and data collection in excess of normal requirements. Can lead to litigation particularly with regard to misuse/mis-treatment of equipment. Additional contractor risks involved in sale and support of products. Must rely upon user to provide data for assessments [2:A9].

Reliability Improvement Warranty (RIW).

Description. The contractor must repair all specified failures to warranted equipment. A MTBF figure can also be negotiated. This warranty motivates the contractor to increase the time between failure for the equipment in order to decrease his costs in frequent equipment repair (2:A10).

Advantages. Provides additional assurance that program will achieve reliability goals. Increases probability of lower life-cycle support costs. Opportunity to increase profits. Contractor opportunity to learn about equipment failure modes in operating environment [2:A10].

Disadvantages. MTBF guarantee approach may not provide strong enough incentive to improve reliability. Increases data collection and administrative requirements. Increased contractor risks over conventional acquisition approaches [2:A10].

Mean Time Between Failure Verification Test
(MTBF-VT) .

Description. The Air Force measures the MTBF of fielded equipment and compares this to negotiated target MFBFs. Differences between the two figures then are the basis for rewards or corrections (2:All).

Advantages. Equipment reliability is enhanced; Ensures careful and comprehensive design effort on most critical performance elements of systems or equipment; Extends contractor responsibility to field use [2:All].

Disadvantages. "Operational verification tests may interfere with initial training or unit mission performance [2:All]."

Availability Guarantee.

Description. To reduce the "down time" of an important system, the Air Force holds the contractor responsible for the guaranteed equipment to be "available"² in operationally ready configuration for a negotiated period of time (or rate as measured by random sampling). The contractor can reach this availability parameter through providing extra no-cost spares, modification, or redesign (2:Al2)

Advantages. Extends contractor responsibility to field use. Measurement parameters are clearly defined and relatively easy to administer. (2:Al2)

²See footnote page 82.

Disadvantages. Selection of sample size and period/duration of testing are critical to prediction of availability (2:A12).

Logistics Support Cost Guarantee.

Description. In order to control selectively critical components of the LCC of a system, the contractor guarantees parameters of these components to reach negotiated values. If as measured in the operational environment these parameters do not match the agreed-to values, then corrections, replacement or other incentives are administered (2:A13).

Advantages. Establishes specific support cost targets prior to production. . . . Causes both the contractor and Air Force to consider reliability, maintainability, and overall support costs as a major item during the design and development stages [2:A13].

Disadvantages. Contractor risk is increased due to uncertainty of predicting proposed equipment characteristics. . . . Disputes may arise concerning the adequacy of Air Force maintenance and data collection during operational verification testing [2:A13].

The last two contract provisions deal with the important and expanding software area. Contractual techniques are needed in this area to promote greater standardization and integration of software among various systems. Also needed are techniques that force the contractor to consider future planned modifications to the software as increased capability via new technology becomes available.

The two current software oriented contract techniques include:

Software Design Commitment.

Description. To improve planned software development and software maintainability, the contractor is motivated to design such features as modular packages, test packages, and extensive code documentation (2:A23).

Advantages. Lower support costs for software. Pre-production assessment or update capability. Early identification of critical features of software. Improved opportunities for common designs. Better cost estimates for production and subsequent software maintenance [2:A23].

Disadvantages. "Standard metrics and measurement procedures not readily available for software [2:A23]."

LRU Configuration Control and Support Agreement.

Description. If any need for software modification results from contractor-induced hardware change, software errors, or inability to meet system performance parameters, the contractor will perform or fund the necessary change at his expense (2:A24).

Advantages. All required reprogramming would be accomplished at no change in cost for a specified number of years of operation. Contractor retains configuration control [2:A24]."

Disadvantages. Potential conflicts with any organically performed "upgrades" to the software or needs to "improve" or "expand" capability beyond contract requirements [2:A24].

Full Scale Engineering Development
Phase Summary

The Acquisition Process. Beginning with a favorable Milestone Two decision, the Full Scale Engineering Development (FSED) Phase contained activities aimed at further refining the weapon system and developing a complete support system. The updated Program Management Directive (PMD) and the AFSC Form 56 gave additional direction and constraints on the development of the weapon system and its support system. The emphasis of the acquisition activity was to prepare a system for operational use that is producable at as low a cost as possible, without sacrificing overall performance or equipment quality.

The Weapon System. The weapon system during FSED takes on a near final appearance, including the many items of support equipment. Design Verification Reviews such as the Preliminary Design Review (PDR), checked the weapon system for overall feasibility and compliance with performance and design specifications. By the end of FSED the government (SPO) has a weapon system and all support subsystems in near operational form, ready for a production decision (16:3.11).

The Working Level LCC Manager. In FSED the working level LCC manager was concerned with the weapon system support being developed in the most overall cost

effective manner possible. This called for such activities as procuring common Air Force support equipment, using the results of reliability, maintainability and failure mode testing to influence internal self test, external diagnostic equipment, and maintenance procedure design. In addition, the working level LCC manager was concerned that critical logistics parameters of the weapon system were tested prior to production, and that selected parameters were warranted or guaranteed by production contractor.

The requirements that impacted the working level LCC manager and the procedures that were needed to fulfill these requirements are given in Figure 9.

Production Phase

During the Production Phase the working level LCC manager will be concerned with two primary tasks. The first task is to evaluate Engineering Change Proposals (ECPs) to the weapon system and their impact on the system's LCC. The second task will take place late in the Production Phase. This task is to finalize and implement the LCC Verification Test Plan.

Engineering Change Proposal (ECP) Review and LCC Verification

This procedure is broken into two parts. The objective of the ECP Review is to:

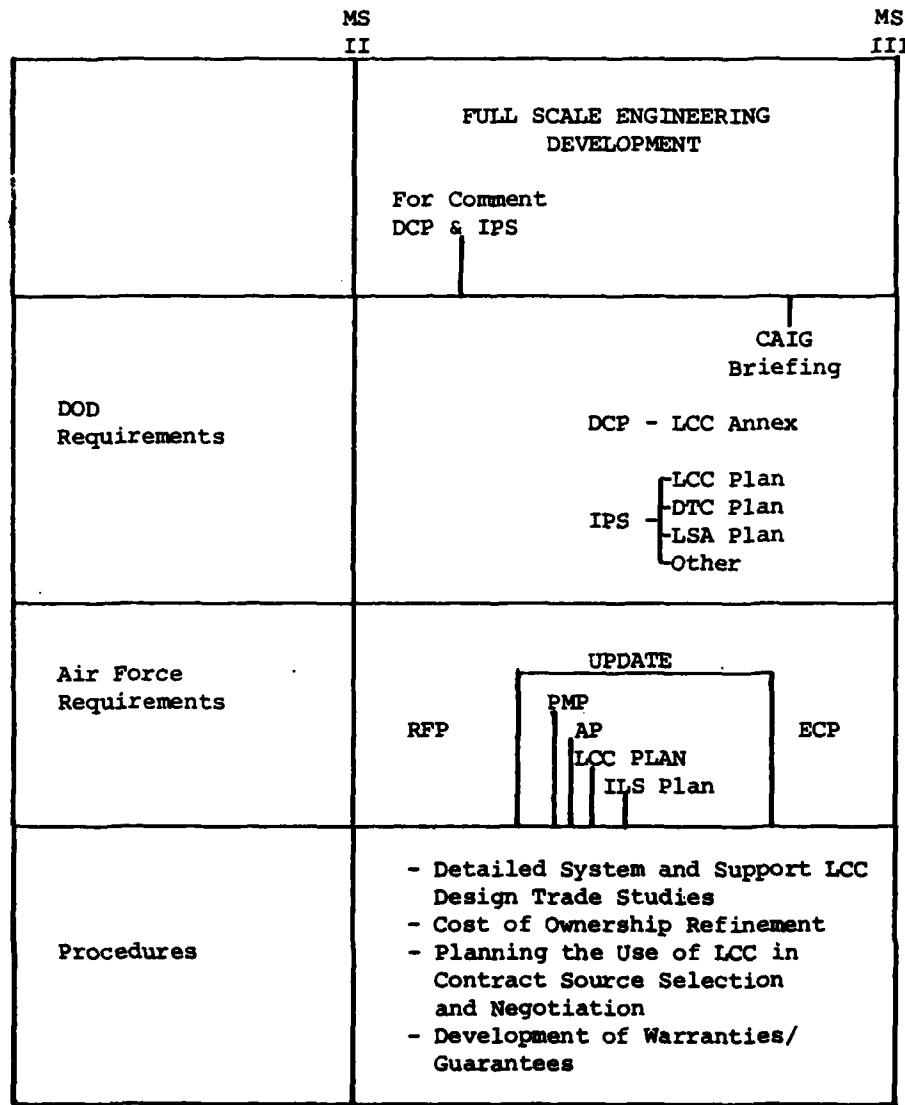


Fig. 9. Full Scale Engineering Development Phase Requirements and Procedures

. . . provide estimates of life cycle cost differences and assess the cost implications of proposed changes so that the decision to accept or reject the Engineering Change Proposal can be made with the knowledge of the life cycle cost implications [16:4-32].

The second part of this procedure refers to estimating the LCC of the weapon system by actual measurement from operational systems of certain logistics parameters. Techniques that support this procedure include:

LCC Model.

Description. LCC models have been described on page 44.

Advantages. An ECP, if enacted, will change various engineering and logistics parameters in the production system. By inputting these parameters into a detailed LCC model the cost impact of the change can be estimated.

Disadvantages. One of the greatest drawbacks to running an LCC model at this point in the program life is the scarcity of data. It is too late in the program to rely on parametric data, and yet it is too early to depend on actual logistics measurement from operational use of the system.

Information Sources. AFALD/XR and the LCC Management Group in ASD/ACCL are good sources of information on using LCC models to perform ECP Reviews. Sources for input include AFLC systems D056 and K051. In addition, civilian contractors maintain historical data on analogous

weapon systems they have developed. In the near future the VAMOSC II system in AFLC/LD will have this type of data available in automated form (see Appendix B for discussion of VAMOSC II).

LCC Verification Test Plan. The LCC Verification Plan is implemented in this phase. See page 70 for description, advantages, disadvantages, and information sources.

Production Phase Summary

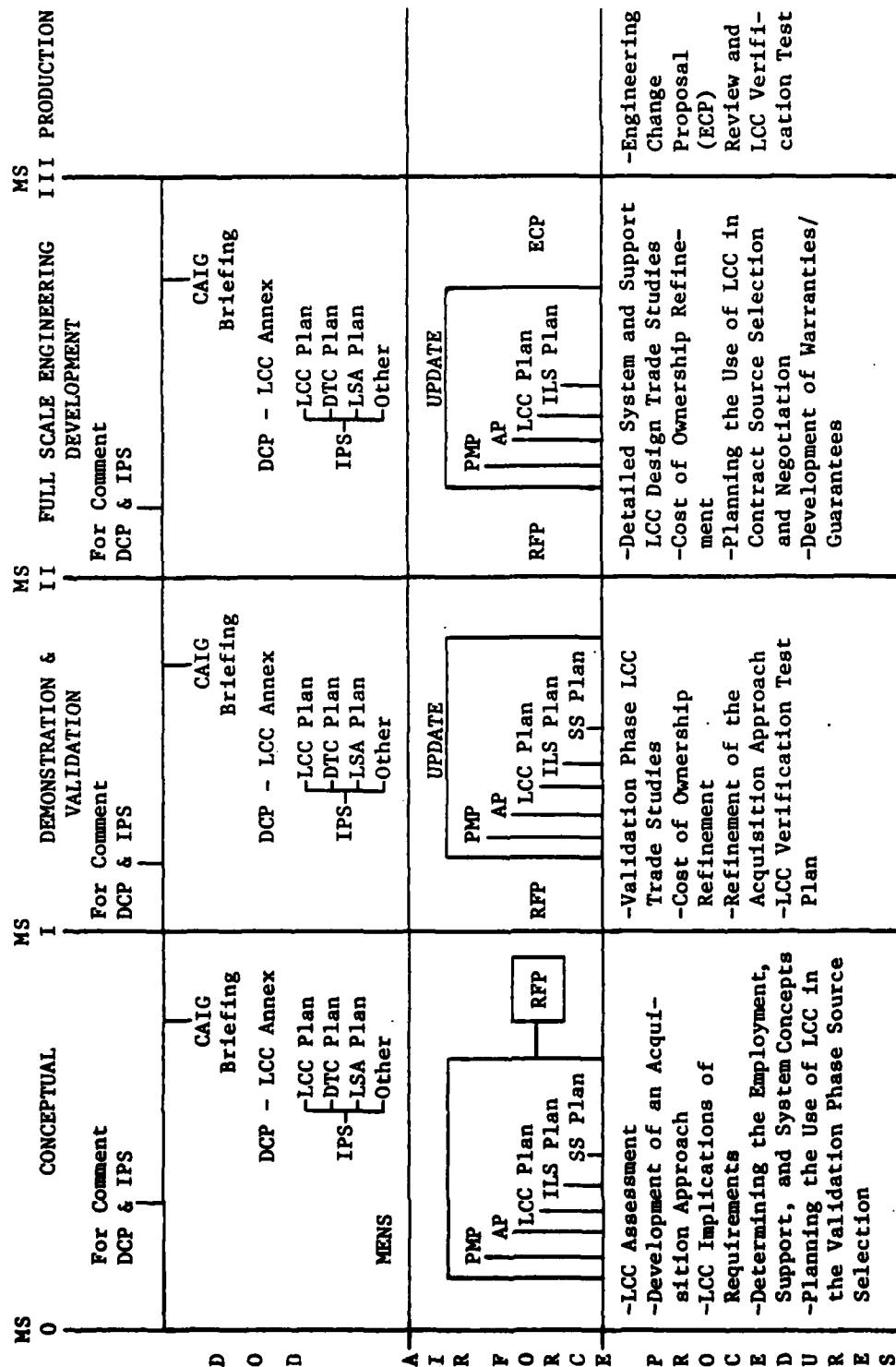
The Acquisition Process. The Production Phase began with a favorable production decision at Milestone Three. During this phase a fixed-price type of contract is typically used to motivate the contractor to hold down production costs. During the production run a Physical Configuration Audit (PCA) is performed to compare the actual system to the detailed design and production specifications. Extensive testing, including reliability, maintainability, and LCC verification takes place throughout production for purposes of correction or contractor awards. Since the weapon system is basically in final form, any proposed changes to the system are rigorously screened for cost/benefit.

The Weapon System. The weapon system during this phase transforms from a "hand-crafted" system to mass produced units. The emphasis with the weapon system is to

take advantage of the economies of scale of a large manufacturing process.

The Working Level LCC Manager. In order for the SPO to reap the benefits of economies of scale the working level LCC manager assists by screening Engineering Change Proposals (ECPs) to prevent a change that is not cost effective from interrupting the production line (a very costly occurrence). Much responsibility for weapon system quality control and LCC control shifts to the Air Force Plant Representative (AFPRO) and Defense Contract Administration Services (DCAS). Late in the Production Phase, or possibly even in post-production, the working level LCC manager will implement a LCC Verification Test Plan to check the LCC of the operational system as measured by actual demonstrated logistics parameters.

The requirements that impacted the working level LCC manager from the Conceptual Phase through the Production Phase, along with the procedures that were needed to fulfill these requirements are summarized in Figure 10.



CHAPTER V

LCC--A WORKING LEVEL APPROACH

This chapter is designed to describe those management actions that a working level Life Cycle Cost manager should initiate to fulfill the requirements of a Design to Life Cycle Cost program during each phase of a major weapon system acquisition. For purposes of a common starting point, it will be assumed that the working level LCC manager is assigned to the System Program Office almost immediately after the SPO cadre is formed. This is a necessary assumption to ensure that the working level LCC manager is involved from the very beginning of the acquisition process where Life Cycle Costing can have its greatest effect. It must also be assumed that this working level LCC manager knows the terminology of the acquisition process.

In Chapter III, LCC requirements documented in the multitude of DOD/USAF documents were identified. In Chapter IV, various procedures and techniques, documented in numerous publications and pamphlets, were identified and discussed as to their purpose, and the advantages and disadvantages of their use in pursuing a Life Cycle Cost program. This chapter attempts to provide order to this plethora of documentation and give the working level LCC

manager a management guide on the design and implementation of an LCC program during each phase of a major weapon system acquisition. This chapter will not be a step-by-step LCC procedural guide due to the fluid nature of the acquisition process, but rather, it will represent the typical management actions a working level LCC manager should pursue.

Working Level LCC Manager Qualifications

Under the present (typical) organizational structure (Figure 11) of a System Program Office, the Program Manager has ultimate responsibility for the project, but has delegated his authority to various divisions aligned according to functional specialties. Program Control is responsible for overall systems program planning, programming, collection of cost and schedule data, performance reporting to higher levels of management and financial management (12:169). Within this division, as suggested in AFSC/AFLC Supplement to AFR 800-11, the Program Manager should establish an LCC focal point with the following duties:

1. Ensure that inputs to LCC analyses reflect current approved program and budget estimates.
2. Ensure that a current system LCC estimate exists and is based on current force planning, program direction, and fiscal guidance.
3. Ensure that cost-related design goals are established for both system and support system design characteristics.

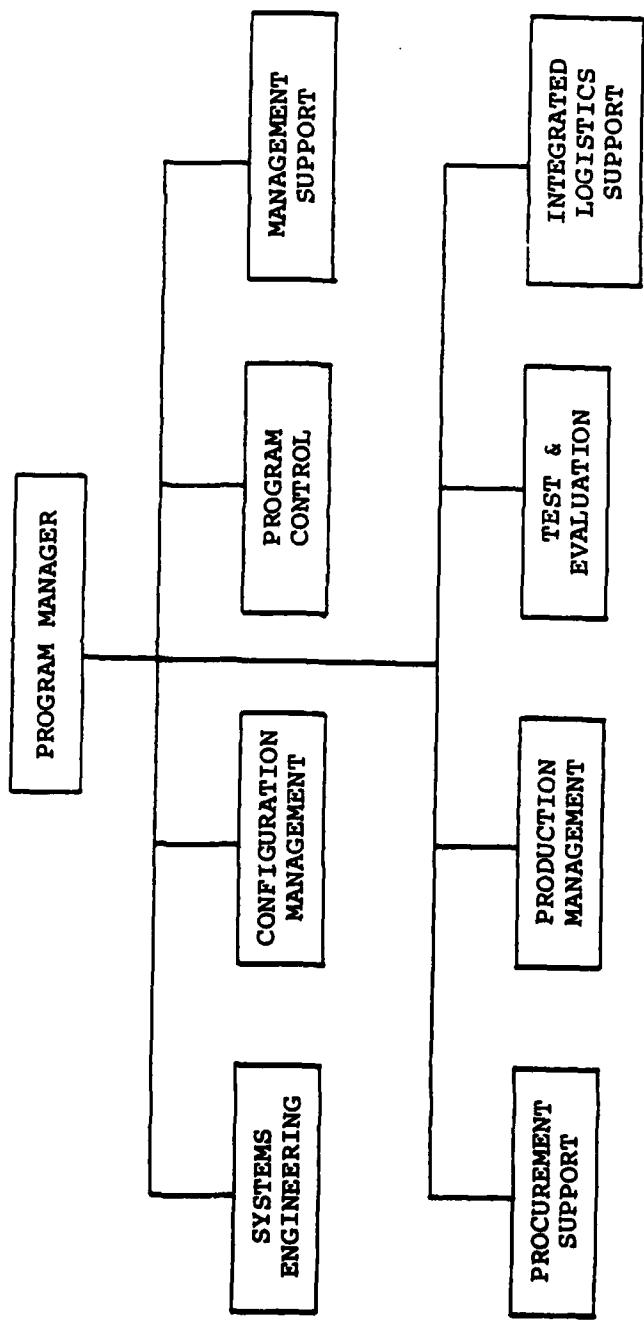


Fig. 11. Typical SPO Organizational Structure

4. Ensure LCC contracting techniques are applied.
5. Ensure that proposed Engineering Change Proposals (ECP's) are analyzed for LCC impact and that the results are considered as part of the Configuration Control Board evaluation.
6. Ensure that major LCC issues are subject to contractor or government LCC trade studies.
7. Ensure that LCC estimates presented during program reviews are consistent and compatible with current program baseline and reflect the potential impact of major program design, schedule, performance and price.
8. Ensure LCC related contract administrative tasks are coordinated [28:2].

These duties, as listed, are broad in scope and imply that the LCC focal point should be a highly qualified individual who is experienced in LCC analysis, Design to Cost concepts, contract incentives, warranties, ECP evaluation, and trade study analysis. As will be discussed in greater detail in the Findings and Conclusions chapter, some individuals who are presently assigned as LCC focal points are very inexperienced, thereby creating the attitude within the SPO, that the concept of Life Cycle Costing is not important. Further, because of the LCC manager's workload and inexperience, other divisions are often not provided necessary and appropriate LCC expertise and service. This set of circumstances has fostered the image that a Life Cycle Costing management program is synonymous with the running of an LCC model; yet nothing could be further from the truth. The Program Manager determines the priority that is given to the concept of Life Cycle Costing. It is understandable that the present environment of the acquisition

process makes it extremely difficult to trade front-end cost for reduced operating and support costs. But if a Life Cycle Cost program is handled properly using appropriate LCC procedures and techniques, the working level LCC manager will provide the Program Manager with more complete and accurate information with which to make the necessary tradeoff decisions.

LCC Philosophy

In the past SPO environment, there were engineers and there were logisticians, each in their own worlds working their own problems with little communication between them. To help bridge this gap, the concepts of Integrated Logistics Support (ILS) and Logistics Support Analysis (LSA) were developed. Logistics Support Analysis is the joint engineer/logistics discipline, working in the System Engineering process, that attempts to transform an operational need into a weapon system that has been optimized from a Life Cycle Cost perspective. The point is that these concepts (ILS & LSA) were conceived to foster a level of integration between all functional divisions that did not exist before. So too must it be for the working level LCC manager. The working level LCC manager's key to success is achieving a high level of integration with all functional branches within the SPO and providing a

SERVICE, a level of analysis that may not currently exist within their division.

In today's SPO environment, the degree of specialization within each division to handle complex weapon systems is quite extensive. It is impractical to have engineers who are experts in logistics and costing concepts and logisticians who are experts in engineering and costing concepts. Thus, the working level LCC manager must establish himself as a link between these areas of expertise. The working level LCC manager's job is to provide information to the Program Manager by which to evaluate both engineering design concepts and logistics support concepts. To do this successfully, the working level LCC manager must fully understand that Life Cycle Costing is a service-oriented function. To make LCC a viable concept, he must integrate with the other divisions and provide them a level of information in the "detail required." The words "detail required" are tremendously important. The working level LCC manager must understand that, for example, in the Conceptual Phase, the engineers and logisticians are dealing with broad concepts involving great uncertainty. The working level LCC manager must be sensitive to the needs of the moment and provide the level of analysis that suits the situation. Otherwise, the concept of LCC will be considered inflexible and a waste of time. Some divisions in the SPO may not understand the concept of Life Cycle Costing and

may even reject the concept entirely. But it is the task of the working level LCC manager to be an advocate and foster the concept that LCC is a tool which can bring different elements of system acquisition to a common baseline from which a decision can be made.

From this discussion it is evident that the person who becomes the working level LCC manager cannot be a novice in the acquisition business. The person assigned the duties of LCC must have a thorough knowledge of the acquisition process, and the responsibilities of each division of the System Program Office. Reducing acquisition and ownership costs is ultimately the responsibility of everyone in the Program Office, and the working level LCC manager must accomplish his work across all divisions, integrating many disciplines and program goals. The working level LCC manager need not be an expert in all the procedures and techniques identified in Chapter IV. But he should understand the concepts and know where to locate experts who can perform the required analyses.

Conceptual Phase (MENS-DSARC I)

Having established the concept of what the philosophy of a working level LCC manager should be, it is now possible to go through the acquisition process phase by phase and describe the management actions that should be taken in implementing a Life Cycle Cost program. In the

following pages, it will become evident that the heaviest workload is in the Conceptual and Demonstration/Validation Phases. During the Conceptual Phase, the working level LCC manager must develop an LCC strategy for the entire program and communicate this strategy and its requirements to the other divisions, and through the RFP, to prospective contractors. Once this initial RFP is responded to and a functional baseline is established, the working level LCC manager should be deeply involved in the continuing System Engineering process to develop a System Specification. Once this point has been reached in the acquisition process, further analysis serves essentially to refine previous design acquisition decisions. This is consistent with the generally held belief that by the end of the Validation Phase, approximately 85 percent of the total life cycle costs of a weapon system have been determined (7:36).

The Conceptual Phase is primarily concerned with the identification and systematic exploration of alternative solutions to the need that has been documented in the MENS. Within the annexes of the Statement of Need (SON) is the Mission Element Need Analysis (MENA), which is based on a document called the System Operational Concept (SOC). The SOC, prepared by the using Command and coordinated throughout the Air Force, documents the planned employment, operating, and support concepts for the weapon system being

envisioned (31:41). Prior to the issuance of the MENS (except in rare cases) there has probably been some advanced development research work done in AFSC's project offices, or the using Command's planning offices to explore various system alternatives. Following approval of the MENS, Headquarters USAF, through a Program Memorandum Decision (PMD), and Air Force Systems Command, through an AFSC Form 56, establish a set of program objectives and constraints under which the Program Office will function. Examples of such guidance can include: performance and schedule requirements, budget constraints, Design to Cost goals, Life Cycle Cost requirements, and any other guidance that these two management levels deem appropriate for successful program accomplishment.

Once a Program Manager has been selected and a System Program Office established, an initial meeting is held to discuss the overall philosophy under which the SPO will operate and to review the PMD and AFSC Form 56. Each program is different and the order of the events described hereafter may vary. The Program Manager's task, in this phase, is to orchestrate an effort which develops a concept as identified in the MENS to solutions proposed by contractors in response to an RFP. From a documentation viewpoint, this is a very hectic phase since, normally, the following four documents are created: the Acquisition Plan (AP), the Program Management Plan (PMP), the Draft

Request for Proposal (if required), and the Request for Proposal (RFP).

The Program Management Plan, as described in AFR 800-2, will reflect the management approach most appropriate to the particular program, as indicated in the PMP and AFSC Form 56 (17:3). The PMP serves as the single baseline management document used by all participating organizations, providing them with information concerning total program planning events, schedules, resources, and objectives to carry out the program.

The Acquisition Plan (AP) represents the acquisition strategy that will be followed by the Program Office in meeting the objectives of the program (34:1-218). This document has tremendous importance to the Program Manager, as it is forwarded to the Secretary of the Air Force and with his approval (Determination and Findings) (D&F) acts as formal negotiation authority to issue the Request for Proposal. Table 5 lists those items that must be discussed in the PMP and AP.

Due to the tight time constraints involved in this first phase, the length of time required to get a D&F, and the complexity of writing an RFP, a new document called a Draft RFP has emerged. The purpose of this document is to solicit contractors' comments on the requirements as specified in the document. This allows the System Program Office to get feedback from the prospective contractors

TABLE 5
PMP AND AP SECTIONS

<u>PMP Sections</u>		<u>AP Sections</u>	
1. Program Summary and Authorization	8. Civil Engineering	1. Description of Program	11. Test & Evaluation Approach
2. Intelligence	9. Logistics	2. Program Funding	12. Program Control Requirements
3. Program Management	10. Manpower and Organization	3. Delivery Requirements	13. Approval for Operational Use
4. System Engineering	11. Personnel Training	4. Applicability of DCP, DSARC	14. List of GFE
5. Test and Evaluation	12. Security	5. Procurement History	15. Application of Should Cost
6. Communications and Electronics	13. Application of Directives	6. Discussion of Program Risk	16. Milestone Chart of Acquisition
7. Operations		7. ILS Concept	17. Milestone Chart for Update of AP
		8. Application of Design to Cost	18. Identification of Participants in AP
		9. Application of LCC	Participation
		10. R&M Objectives	
			19. Procurement Approach for Each Proposed Contract

concerning any areas of the RFP that are unclear and subject to interpretation.

The one document that has the most criticality attached to it is the Request for Proposal. The RFP culminates the initial concept planning process started at the approval of the MENS, and takes the Program Office from the Conceptual Phase to actual proposed solutions. This document must communicate to the contractor the exact need of the Air Force.

Once the RFP is responded to by the contractors, the System Program Office enters Source Selection to evaluate each proposal. During the Source Selection process, it becomes evident to the Program Manager how successfully he and his staff were in communicating the need, as specified in the MENS, to the contractors. The results of the evaluation are summarized into the DCP and IPS and a series of briefings are held at AFSC, HQ USAF, and finally the DSARC review where the decision is made by SECDEF on whether to go into the next phase.

The previous discussion is not intended to be all-inclusive of the events that occur during the Conceptual Phase, but only to serve as a baseline from which, in the next section, the activities of a working level LCC manager can be described.

LCC Activities During Conceptual Phase

As indicated in the discussion of Life Cycle Cost philosophy, the working level LCC manager must perform a service-oriented function. As indicated previously, the working level LCC manager should not be a novice to the acquisition process, or the internal workings of a SPO, but in any case, a review of DODD 5000.1, 5000.2 and AFSCP 800-3 should be helpful. The element that is working against the working level LCC manager, whether experienced or not, is time--time to accomplish all the planning and written documentation that occurs during this phase. Time criticality is the main reason for having an experienced person in this position.

The first objective of the working level LCC manager is to get oriented to the problem at hand. This can be accomplished by a review of the PMD and AFSC Form 56. These two documents can act as the initial baseline for the working level LCC manager from which all other information can be examined. In addition, a review of the MENS and MENA will give the working level LCC manager some concept of how the using Command envisions the weapon system being operated and supported.

Through a thorough review of the System Operational Concept document, the working level LCC manager will be able to update his initial baseline with such factors as performance, anticipated tactics, availability

(reliability and maintainability), mission scenarios, deployment concept, manpower, logistics, and many others. These parameters of operational and support concepts become very important inputs to an LCC model. A review of these studies accomplished during the Advance Development effort may add additional information to the initial baseline. These studies are not readily available in the SPO, but can be located through the appropriate project offices at AFSC. The studies will help the working level LCC manager understand the technology base that has been explored in developing this particular concept, especially those areas of technology that may have proved infeasible. There are two offices, "Lessons Learned" (AFALD/PT) and the "Product Performance Feedback System" (AFALD/PTA) that will also help the working level LCC manager familiarize himself with the problem. As its name implies, "Lessons Learned" office is a source of information concerning lessons, both good and bad, that have been learned from previous acquisition programs. The "Product Performance Feedback System" (AFALD/PTA) can provide historical data, both cost and engineering, concerning various subjects. A visit to each office would add knowledge and may prove a helpful update to the baseline of knowledge that the working level LCC manager is trying to establish.

It may seem that the working level LCC manager is getting into areas that are beyond his area of

responsibility, but it is important to remember that he must be able to effectively integrate with the other divisions. The level of knowledge that is acquired through this effort will enable him to: (1) become familiar with the overall system concept and the level of technology required to meet the problem; (2) understand the terminology of the other divisions so that time is not spent in trying to establish a common "language" for interface; and (3) understand what has been tried before and proved infeasible, so that time is not spent trying to reinvent the wheel.

Soon after the SPO has been established, a Business Strategy Panel meeting is held to enable all participants to be aware of lessons learned from recent major programs and to promote discussion of innovative strategies to meet program objectives (30:3-8). The meeting is usually held during the formulation of the Acquisition Plan and can also serve as a means of coordination between the divisions on the plan. The working level LCC manager, who has done his homework (as described in the previous paragraphs) will be able to attend the meeting as an active participant instead of an observer. One fact is beyond dispute, the working level LCC manager provides a service to the other divisions. To provide an effective and efficient service, he must be able to communicate with the other divisions, and understand what each division is involved in at any given time period,

including the constraints they are operating under. Only if the working level LCC manager is armed with this knowledge will he be able to accomplish his job of implementing an LCC program.

As the System Engineering process begins in the SPO, the working level LCC manager will be involved in formulating the LCC sections of the PMP and AP. As discussed earlier, the Program Management Plan is a document which outlines the management approach most appropriate to the particular program, as indicated in the PMD and AFSC Form 56, while the Acquisition Plan represents the acquisition strategy that will be followed in meeting program objectives. An ASD Supplement to AFR 800-11 indicates that if program complexity dictates, a separate Life Cycle Cost Management Plan can be developed (22:4). For the working level LCC manager, this is an opportunity to lay out in detail a plan of action for pursuing the consideration of LCC as a viable parameter in each phase of the acquisition process. An acceptable starting point in this endeavor is to review previous LCC Management Plans such as, the Advanced Medium Short Takeoff and Landing Program (AMST) and the C-X Program. The critical point to remember is that LCC standing alone is not a valid concept; LCC must be integrated into the other divisions and become a design and logistic tool by which potential systems' alternatives are evaluated. As documented in Chapter III,

and ASD Supplement to AFR 800-11, a LCC Management Plan must document:

1. Methods to make LCC an integral part of the program decision making process.
2. Specific tasks and milestones related to LCC management.
3. Planned method of addressing LCC considerations during source selection.
4. Planned method of establishing Design to Cost goals.
5. Major trade studies anticipated.
6. Cost estimating, tracking, and verification procedures.
7. Planned contractual techniques to support LCC objectives [26:4].

Since the LCC Management Plan should act as an outline for the working level LCC manager in creating the AP as well as the Request for Proposal, these items bear further discussion. First, item one: "Making LCC an integral part of the decision-making process." DOD 5000.1 and 5000.2, as well as OMB Circular 109, make it mandatory that LCC is briefed at all program reviews, to the CAIG, and the DSARC review. The working level LCC manager must outline in the LCC Management Plan the methods of ensuring that the contractor, as well as the SPO, will consider LCC in the design process. This may involve the use of LCC models, special reporting procedures, contract incentives, or cost benefit analysis. The point is that the working level LCC manager must devise a methodology to make Life Cycle Costing a factor in both the contractor's and SPO's decision-making process. Once this methodology has been determined, the individual tasks as outlined in the remaining six items

support the execution of this methodology. The importance of the LCC Management plan cannot be overemphasized. It is the management tool by which the working level LCC manager will be guided throughout the acquisition process. If the six items as listed in the ASD Supplement to AFR 800-11 are researched fully and addressed in full detail for each phase, then the working level LCC manager's actions will simply be an execution of this plan.

The method of addressing LCC considerations in the Source Selection process is a major point. In the LCC Management Plan the working level LCC manager will provide the general outline of the process, but in the Source Selection Plan, this area must be covered in detail. Of even greater importance, the working level LCC manager must communicate to the prospective contractors (in the RFP) the importance and methodology of evaluation for Life Cycle Cost, so they may respond properly.

Because the concept of Life Cycle Costing has only been applied in a comprehensive sense to two major weapon system acquisitions (A-10 and F-16), there is not much data on the subject of verification testing. In the F-16 Program, the AFLC LSC Model was utilized as a major tool in developing LCC estimates and in evaluating contractors' proposals. Part of the LCC Management Plan was to establish a set of Line Repairable Units (LRUs) that were the high cost drivers of the system and establish Target

Logistics Support Cost figures. These targets would then be tested after an agreed upon time period to determine if the LRUs met the established goal. If the LRU did, the contractor was awarded an incentive; if the LRU did not, the contractor had to replace the units under a Correction of Deficiency clause. It is not possible to report the effectiveness of this test, for due to changing events, the Verification Test has been delayed. The point is that, even though it is the Conceptual Phase, it is imperative to structure a LCC management Plan through all phases of the acquisition. If this baseline is established, it will be much easier to update the baseline as more facts become known.

The process of Engineering Management is what transforms a military requirement, as cited in the MENS, into an operational system. (This process refers to the management and technical functions within a Program Office that must be fully integrated to meet the program objectives.) Within this process, the balancing of system performance, life cycle costs, schedule, producibility, supportability, reliability, and maintainability must be combined. The Engineering Division of the SPO will consist of many functional areas, of which Systems Engineering, Design Engineering, Test, Production Engineering, and Logistics Engineering are but a few. It is within Systems Engineering and Logistics Engineering divisions

that the working level LCC manager must embed himself during this phase.

The Systems Engineering function is a major part of any program in the Conceptual Phase. The objective of Systems Engineering is to achieve a proper balance among operational, economic, and logistics factors (30:3-14), seeking to design a product that is serviceable, operable, and meets the need. The work of Systems Engineering includes aspects of Logistics Engineering, Engineering Integration, and Logistics Support Analysis, all of which are trying to ensure that the system designed is a supportable and cost effective system. Logistics Engineering utilizes the technical data generated by Systems Engineering to define maintenance, reliability & maintainability (R&M) factors, and support concepts for the system. The concept of Logistics Support Analysis (LSA) was designed to be the connecting link between the engineer and the logistician, so that the design conceived is able to be supported at the lowest overall cost. The LSA team works from a computerized data storage bank called the Logistic Support Analysis Record (LSAR). This data bank is an excellent source of logistics data for the working level LCC manager. In the near future this data will be further automated and available through the Product Performance Feedback System (AFALD/PTA).

The Integrated Logistics Support (ILS) division--the parent organization for the LSA work group--is deeply involved in the Systems Engineering process, but is working under conditions of great uncertainty. Since a piece of hardware is yet to be designed, the ILS function can only work with conjectures, but at the same time must explore all system support concepts that eventually will be a requirement in the Request for Proposal. The real effort of this division, through LSA, is to make sure that the system being designed in the System Engineering arena is in fact a supportable system.

It is during this time period of System Engineering, and formulation of the PMP, AP, and SSP that the working level LCC manager will be the busiest. By the same token, it is during this time period when he can have the most effect on the LCC of the program. As alternatives are developed in the System Engineering process, they will have to be evaluated to determine which is the most effective. For the working level LCC manager, this means providing an LCC assessment to bring the different alternatives into a common perspective. By no means are the authors implying that LCC should be the sole determining factor in evaluating differing alternatives, but LCC should be a consideration in balancing performance, schedule, and cost. Due to the levels of uncertainty involved during this phase, the working level LCC manager must understand the

"detail required" in his LCC analysis. Appropriate techniques for this phase would include parametric model estimating, analogy, risk analysis, and simple LCC models. The lack of certainty, especially in the area of logistics concepts, will force the working level LCC manager to deal in gross estimates. The important point for the working level LCC manager to remember is that he is providing analysis results to engineers or logisticians which they will use, as an additional consideration, to evaluate alternatives. The result of the System Engineering effort is a Preliminary Work Breakdown Structure (PWBS) which will eventually become part of the Statement of Work (SOW) in the RFP.

During the time period when the PMP and AP are being developed, and the Systems Engineering process is in progress, the Data Management Officer (DMO) within the SPO is identifying data requirements and developing the Contract Data Requirements List (CDRL). The DMO is required to contact all potential data users within the program office, the using Command, the support Command, and the training Command, to obtain data requirements for each separate program phase and contract. This effort is referred to as a "Data Call." Although the DMO has the basic responsibility to collect the data requirements from the various divisions, it is up to each division to determine their data requirements and identify them to the DMO. For the

working level LCC manager, this means he must, also, identify his data needs and the format the data should be in. This action will require coordination with the other divisions, since their outputs represent the inputs to his LCC analysis. An important point that must be remembered is that if the SOW directs a task which generates data and the data is to be deliverable, it must be identified in the CDRL.

All effort so far in the SPO has been leading toward the formulation of the Request for Proposal (Figure 12), the document the SPO utilizes to communicate to the prospective contractors what the government wants, subject to certain constraints. For the working level LCC manager, the RFP represents the execution of the first part of the LCC Management Plan and is indicative of his success in communicating LCC objectives and considerations to the various divisions of the SPO. If these divisions include a requirement in the RFP that was not evaluated under LCC concepts, the working level LCC manager has not done the proper job. Table 6 indicates the format by which the RFP is structured (30:2-13). Sections H, J, L, and M are important sections for the working level LCC manager.

In Section H, "Special Provisions," are contained the special and unique clauses which apply to the contract, such as LCC Support Provisions, Warranties or any contract language that will be used to implement incentives for

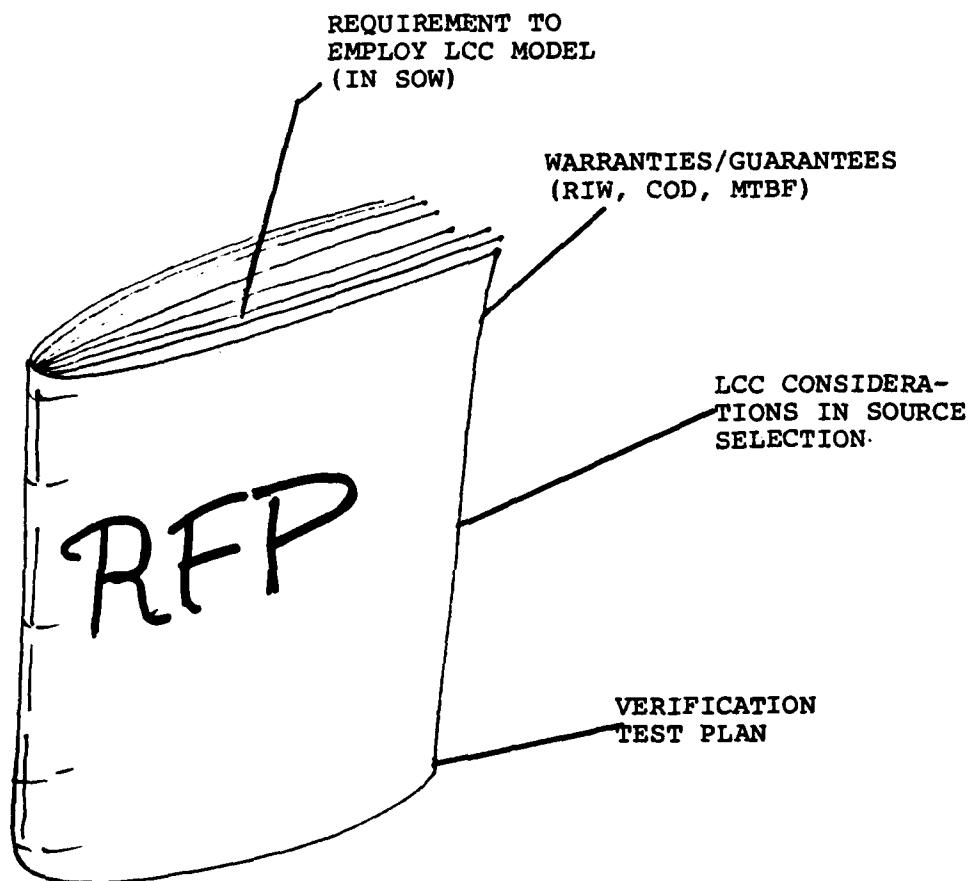


Fig. 12. LCC Oriented Inclusions in the
Request for Proposal (RFP)

TABLE 6
RFP FORMAT (30:p.2-13)

Executive Summary

Part I SCHEDULE

Sec

- A** Contract Form
- B** Supplies/Services Prices
- C** Description/Specifications
- D** Packaging and Marking
- E** Inspection and Acceptance
- F** Deliveries or Performance
- G** Contract Administration
- H** Special Provisions

PART II GENERAL PROVISIONS

- I** General Provisions

PART III

- J** List of Documents, Exhibits, and other Attachments

PART IV

- K** Representations, Certifications, and Other Statements of Offer
- L** Instructions, Conditions, and Notices to Offerors
- M** Evaluation Factors for Award

Life Cycle Costing. Section J, "List of Documents, Exhibits and other Attachments," contains the Statement of Work which specifies exactly what the government wants the contractors to do. In this section, the working level LCC manager must indicate how the major cost drivers of the program will be identified, use of a cost element structure, type of LCC model, data requirements, test and evaluation plan for testing LCC, how LCC will be integrated with ILS, LSA, and RLA, LCC Management Plan, subcontractor LCC control and any other items the working level LCC manager believes are necessary to implement Life Cycle Cost concepts into the program. Section L, "Instructions, Conditions, and Notices to Offerors," is designed for two purposes. First, it gives the contractors background information needed to understand the overall scope of the program. Second, it gives specific information for preparation of proposals. Contractor's proposals are normally prepared in six volumes:

Vol I General Summary

II Design Engineering and System Test

III Manufacturing

IV Management

V Logistics

VI Cost and Pricing

In each of the volumes, instructions are given as to what subjects will be addressed by the contractor. In Volume IV, the contractor must outline his LCC Management Plan. In Volume VI, the contractor must detail the cost results of all studies and LCC models. The purpose of Section M, "Evaluation Factors for Award," is to convey to offerors the basis for proposal evaluation. For the working level LCC manager this means the explanation of how LCC proposals will be evaluated. For the working level LCC manager, the RFP should be an extension of the LCC Management Plan, Acquisition Plan, and Source Selection Plan. The items specified in the SOW should be the result of the working level LCC manager having interfaced with engineers and logisticians so that the best balance between cost, performance, and schedule were achieved. The results of the proposal evaluation are then summarized, along with the actions for the next phase, and briefed at the DSARC Review.

In working through the Conceptual Phase it is obvious that the working level LCC manager is involved in fulfilling a large number of time-constrained requirements. The procedures and techniques that he must employ, or see that others employ, in order to fulfill these requirements should be very familiar to him. For example, in developing the different strategies and plans (AP, ILSP, PMP, LCCP) LCC assessment techniques help him to determine cost goals

and contract objectives. Cost-benefit analysis, level of repair analysis, and LCC models provide information on gross tradeoffs and potential high cost driving elements to be considered in the structure of the various plans. Parametric techniques, sensitivity modeling and risk analysis can highlight potential trouble areas that should receive special treatment in early formal planning documents.

In preparing the draft RFP, the actual RFP, and Source Selection plan, the working level LCC manager will utilize several specific procedures and techniques. An LCC model can be used to help determine the relative cost importance of different logistics performance parameters in the contractor's design. Sensitivity analysis will give insight into the effect of possible variance in these parameters. Parameters identified as exceptionally important to LCC can be assigned higher weights in Source Selection and be highlighted in the RFP.

The Conceptual Phase chart (Figure 13) summarizes the requirements of this phase and relates procedures that can be used to fulfill these requirements. For detailed information on supporting procedures and subordinate techniques see Chapter IV. The procedures in Chapter IV are discussed in the order shown on the Conceptual Phase chart. Figures 13 through 15 are repeated for the convenience of the reader.

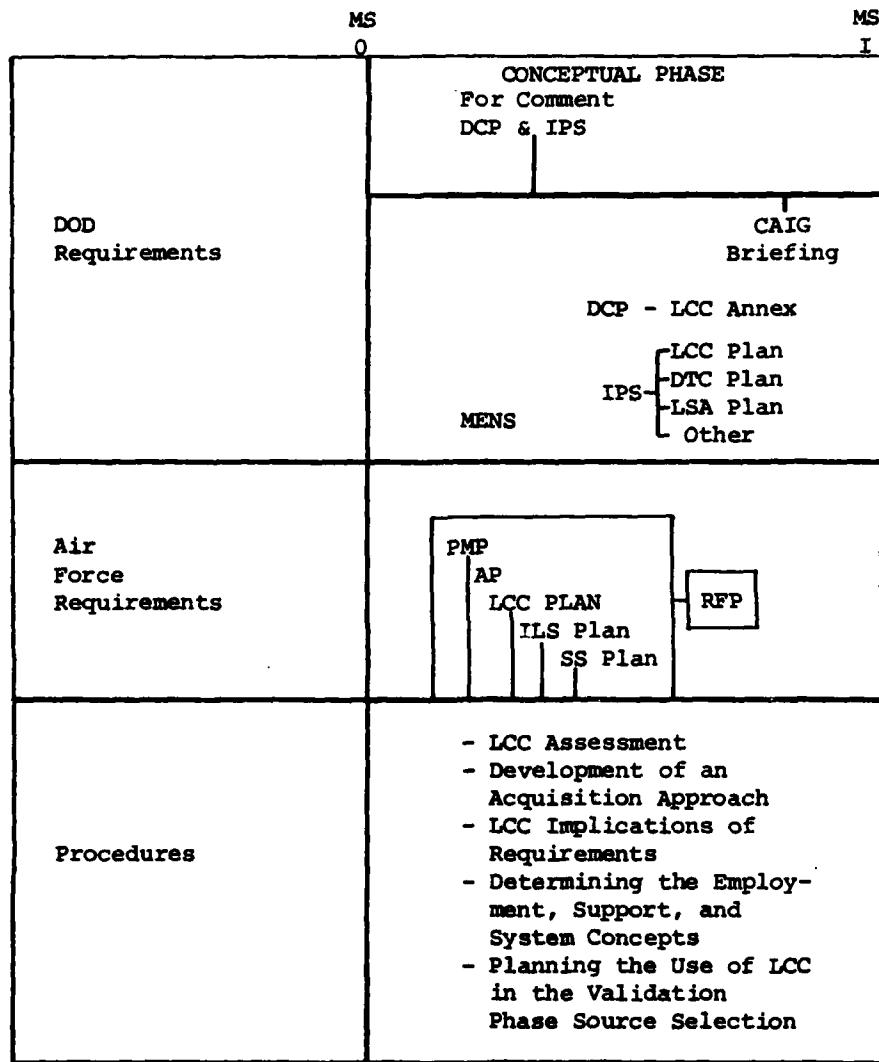


Fig. 13. Conceptual Phase Requirements and Procedures

Demonstration and Validation Phase

At the conclusion of the DSARC review, the SPO has a "functional baseline" for the program. During this phase, the primary concern is refinement of the candidate solutions through extensive study, analysis, equipment development, and testing. The goal of this phase is to establish an "allocated baseline" consisting of firm and realistic system, subsystem, and configuration item performance requirements, and other design constraints, technical data, and program data. During this phase, major emphasis is placed on reducing the technical, cost, and schedule risks and minimizing the logistical support problems of the weapon system. The result is a System Specification detailing how the weapon system and its major subsystems will function.

LCC Activities During the Demonstration and Validation Phase

During the Conceptual Phase, the working level LCC manager is deeply involved in establishing LCC as a viable consideration in evaluating competing alternatives. If the working level LCC manager was successful in implementing LCC in all divisions during this phase, the proposals from the contractors will reflect consideration of LCC in their design and logistic support concepts.

During the Conceptual Phase, engineers and personnel in the Integrated Logistics Support Division were

limited in the degree of depth of their analyses. So too was the working level LCC manager, in that parametrics, analogy, and specialist estimates were the best techniques due to lack of specificity in exactly what the weapon system consisted of. But with the contractors' proposals now in the SPO, the level and degree of analysis attainable is substantially greater. An important point must be made here. During the Conceptual Phase the SPO was in the creative mode, exploring concepts and doing its own analysis on its own designs. But at this point, the SPO is transitioning from the creative mode to an evaluation mode. The majority of the work done from this point on is the responsibility of the contractor. The SPO is now evaluating the work of the contractor as specified in the initial RFP and subsequent RFPs. In the case of the working level LCC manager, this is extremely important to understand. The working level LCC manager is basically reformatting and expanding the LCC Management Plan for input into the various sections of the RFP. If the contractor's proposal does not reflect LCC as a major parameter, if the LCC data are not correctly stated, if the contractor did not consider the use of warranties, or if Design-to-Cost goals or Logistics Support Analysis do not reflect LCC concepts, then the working level LCC manager has failed in the Conceptual Phase and will have to work extremely hard to gain

the contractor's and SPO's attention for future LCC considerations.

For the sake of argument, it is assumed that the working level LCC manager was successful in his efforts of implementing LCC concepts both in the SPO and in the contractor's proposals. As stated before, the goal of the Demonstration and Validation Phase is to reduce the risk involved with design and logistical considerations and to document this result in a System Specification. During this phase, the System Engineering Division will be heavily involved in the analysis of the weapon system structure through an exploration of the major system and subsystems, with major emphasis on performance, reliability and maintainability. The ILS division, during the System Engineering process, will be involved in trying to evaluate the logistics support alternatives that the contractors have proposed with heavy emphasis on identification of logistics support cost drivers. The working level LCC manager should be deeply involved in the Systems Engineering process. During this phase, because the weapon system has become more defined, the number of trade studies required to validate alternative design and support concepts proposed by the contractor will be greatly increased. The detail required in these trade studies will increase, in view of the growing amount of actual component and subsystem

hardware being created. The Accounting LCC Model is one tool designed to support more detailed trade studies.

The overall LCC estimate of the system can be more precisely defined during this phase by inputting more detailed data into cost of ownership techniques such as Engineered Cost Estimating Method, Industrial Engineering Standards, specific analogy, and Accounting LCC models. In the near future the Product Performance Feedback System (PPFS) (AFALD/PTA) will have detailed engineering and logistics performance data from the developing contractor available in automated form for direct input into models or techniques. At the same time, specific analogy estimates will become more accurate in the near future as extensive historical data for analogous systems, subsystems, and components will be available from the VAMOSC II system in AFLC/LO.

The Demonstration and Validation Phase chart (Figure 14) summarizes the requirements of this phase along with the procedures useful for fulfilling the requirements.

Full Scale Engineering Development Phase

Upon completion of DSARC II, the System Specification has been approved. The contractors, in conjunction with the SPO, concentrate during this phase on developing a Part I and Part II Configuration Item Specification. These specifications now become extremely detailed,

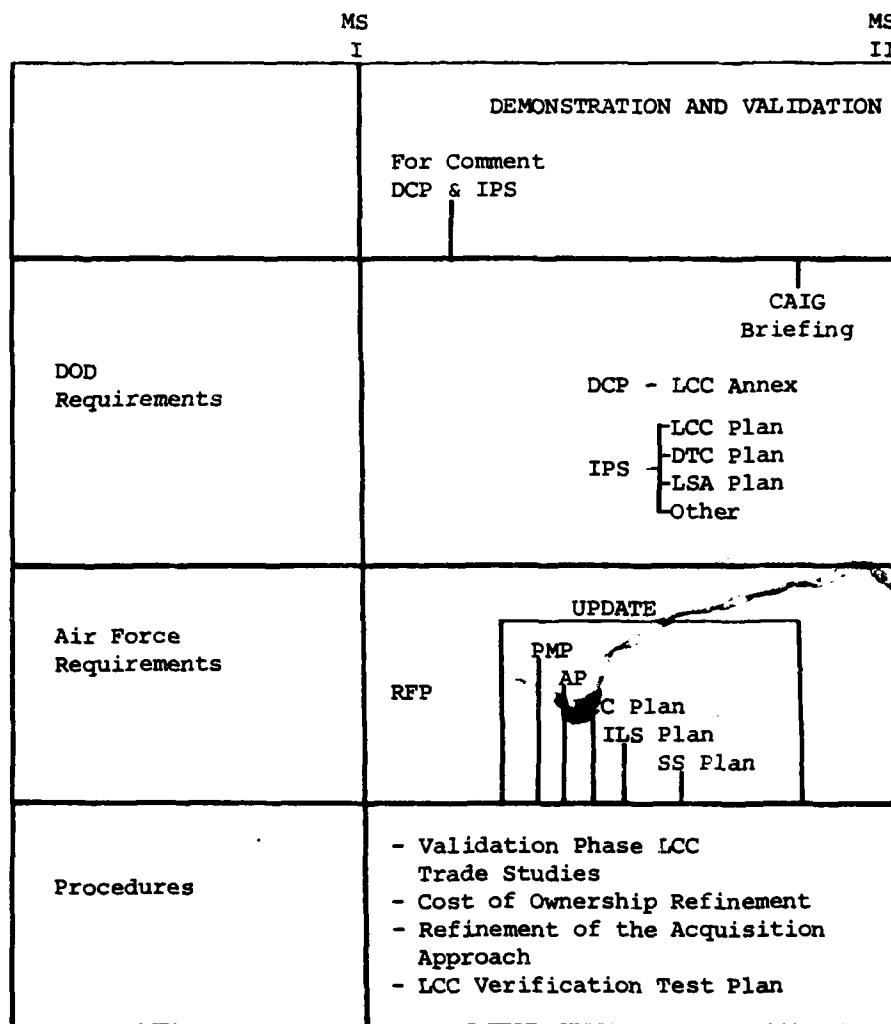


Fig. 14. Demonstration and Validation Phase Requirements and Procedures

breaking the weapon system down into individual systems and subsystems.

LCC Activities During the Full Scale Engineering Development Phase

For the working level LCC manager, the requirements of this phase change slightly from previous phases. The original MENA, updated PMD and AFSC Form 56 indicated the support concept of the weapon system. Up until this phase, however, the weapon system has been a basically hand-built prototype with minimal support equipment and technical data. In the Full Scale Engineering Development Phase the working level LCC manager must ensure that the weapon system has the most LCC-effective support plan possible. This requires that support equipment be, to the highest degree possible, existing Air Force common support equipment. The contractor will likely have developed specialized test and diagnostic equipment by this phase in order to validate parts of his design and establish contract performance. The temptation will be to procure this type of specialized support equipment for the operational system support role. This decision should not be made until all avenues of common test equipment have been fully investigated and the reliability and maintainability of the specialized contractor test equipment assessed. Several of the techniques detailed in Chapter IV are essential to the working level LCC manager in designing an efficient and

effective support system. One such technique is Optimum Repair Level Analysis (ORLA), which is used to assign system components (LRUs and SRUs) to the most economical repair levels of maintenance (field, intermediate, depot, etc.) (29). Another is Logistics Support Analysis (LSA) which provides the necessary data for support system decisions. This data is obtained from the contractor on a Logistics Support Analysis Record (LSAR). The LSAR will be available in automated form from the AFALD/PTA Product Performance Feedback System in the near future. In the interim, the working level LCC manager should require contractors to automate the LSAR and make it available electronically to the Program Office for analysis.

Failure Modes and Effects Analysis is particularly important at this point, in that peculiar test equipment design and special maintenance procedures can be designed in light of specific failure patterns.

In this phase the overall cost of the weapon system should be refined with the detailed logistics and engineering parameters available on the weapon system components and support equipment, as well as knowledge of level of repair, spares costs and manpower requirements. LCC models, Engineered Cost Estimating, Industrial Engineering Standards and Sensitivity Analysis are useful techniques for refining the cost estimate for the weapon system during this phase.

During the Conceptual Phase, the Acquisition Plan, a strategy for dealing with the contractor, was developed in general terms. The design of the RFP, criteria for Source Selection, and negotiation tactics implemented this overall strategy. In the Full Scale Engineering Development Phase the working level LCC manager must take an active part in Source Selection and contract negotiations so as to hold the line on system LCC. Because of the expense of having more than one contractor continue through Full Scale Engineering Development, usually only one contractor is selected to continue into the Production Phase. This places the contractor in a very good "sole source" negotiating position. Since the forces of competition are not present to hold down production contract costs, other techniques must be substituted. One of the most effective techniques is a combination of contract warranties and guarantees that specify target production parameters (MTBF, etc.) and the rewards or penalties for attaining/missing those parameters. In order to successfully implement such contractual techniques, the working level LCC manager must ensure that adequate test procedures are devised to measure the actual logistics parameters in production.

Another relevant technique is Learning Curve Analysis. By anticipating the decreasing rate of contractor production costs on cumulative units of output, as

larger quantities are produced, the government can negotiate lower and more realistic production costs.

During this phase the final details of the post-production LCC testing procedures (Verification Test) should be negotiated with the contractor. The objective of the post-production test is to gather logistics data on the mature, operational system for comparison to previously negotiated targets. The feedback from this test can be used to validate or modify LCC techniques, reward the contractor for exceptional performance, or force the contractor to correct or pay for deficiencies (within negotiated limits). This type of test-feedback-action has not yet been implemented in a major weapon system acquisition. The F-16 post-production test is scheduled to commence in the near future and should provide practical lessons on the usefulness of the technique.

The final concern of the working level LCC manager during this phase is the evaluation of engineering change proposals (ECPs). ECPs this late in the development of the weapon system must be screened with additional rigor for benefit above the cost they required. LCC models, Cost-Benefit Analysis, and Sensitivity Analysis are useful techniques for evaluating the impact of these baseline changes.

The Full Scale Engineering Phase chart (Figure 15) summarizes the requirements and relevant procedures that the LCC manager is concerned about during this phase.

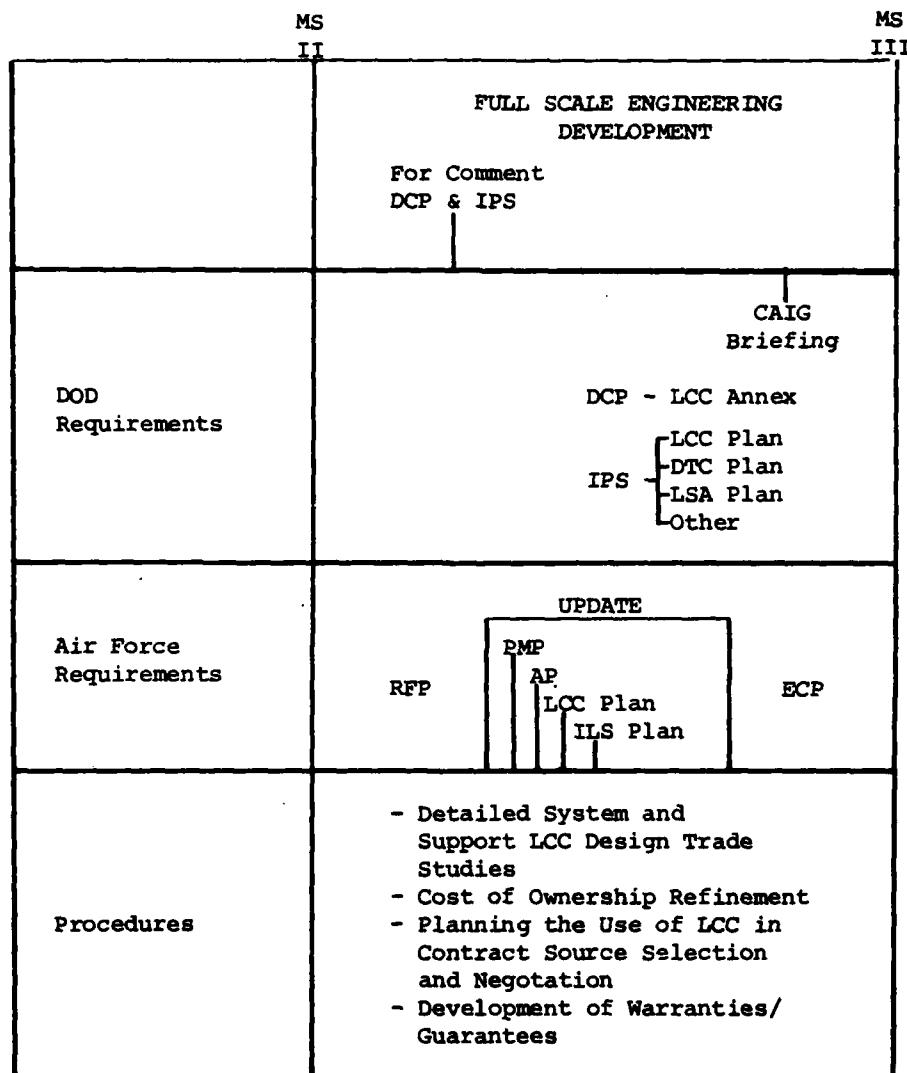


Fig. 15. Full Scale Engineering Development Phase Requirements and Procedures

Production Phase

During this phase, the SPO has moved into the final execution of all its previous plans. The weapon system now has a definite System Specification and Part I and Part II Configuration Item Specifications from which the contractor will build the weapon system in mass production fashion. The point is that a firm baseline has now been established and any changes will be changes to this baseline and not a totally new system.

LCC Activities During the Production Phase

During this phase of the acquisition process the working level LCC manager is concerned with a number of important tasks. ECP evaluation is extremely important now, as changes to a production baseline can be very expensive and the cost-benefit of any change must be evaluated with great care. At this late stage in the program, any change (ECP) must be evaluated from a system perspective to determine the total impact on the weapon system as a whole. The evaluation of an ECP from a LCC perspective will highlight the total impact on the weapon system of any proposed change.

Testing of logistics parameters on actual production systems is important to ensure that unsupportable components are not passed into the operational support environment. Whenever possible, the working level LCC manager

CHAPTER VI

FINDINGS AND RECOMMENDATIONS

This research effort stemmed from a need to integrate the diverse requirements, procedures and techniques confronting the working level LCC manager. In order to accomplish this objective, the research team broke the task into basic elements, investigated the elements, then combined the knowledge gained into an integrated form. The basic elements were the requirements that impact the LCC manager, as well as the procedures and techniques that are useful in fulfilling these requirements. The method of investigation into the broad elements of requirements, procedures and techniques was document analysis and interviews (Figure 16).

The requirements, and the procedures and techniques were analyzed in depth in two separate chapters (Chapters III and IV, respectively). The combination of all three is essential, however, for presenting a complete and practical guide to the application of LCC during each phase of the system acquisition process. This combination was accomplished in two ways. In Chapter IV, "Procedures and Techniques," general LCC procedures were associated with more specific techniques needed to carry out the procedure,

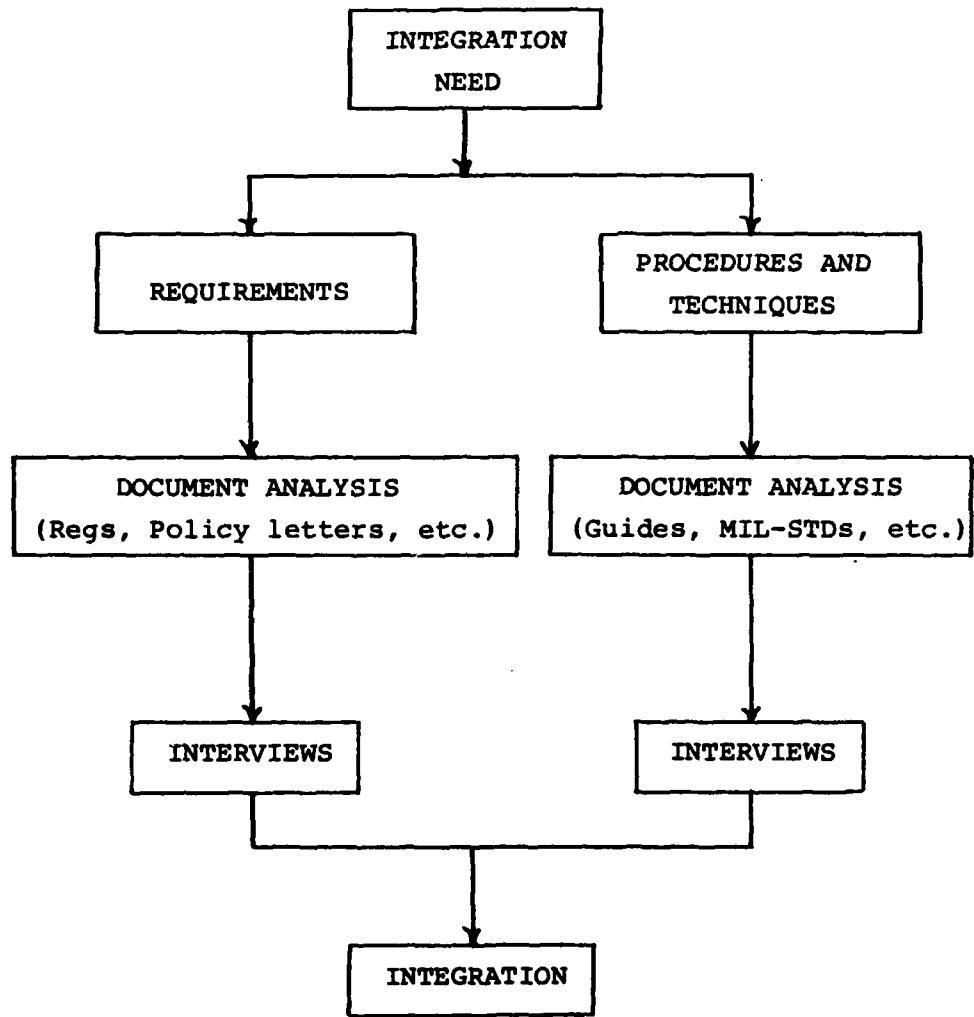


Fig. 16. Method of Investigation

along with advantages, disadvantages, and practical examples of technique employment. The combined procedures and techniques were, with the aid of procurement literature and LCC experts, placed into phases of the DSARC process. The placement of the procedures and techniques throughout the DSARC process was implicitly driven by the requirements on the LCC process, identified and analyzed in Chapter III. Therefore, at the end of the treatment of each phase of the DSARC process in Chapter IV, LCC requirements were matched to relevant procedures and techniques, resulting in a time-line of associated requirements, procedures and techniques organized by DSARC phases of the system acquisition process. This first integrating mechanism can be depicted in tabular form (see Figure 17).

The second integration of the research information takes place in Chapter V, where an example LCC management effort moves through each phase of the acquisition process discussing the practical problems, required actions, and activities a manager must engage in to implement the LCC Program.

Finding: The Working Level LCC Manager

During the year of research, this research team had the opportunity to observe the working level LCC manager. The thrust of the research effort was directed at fulfilling the need of working level LCC managers for

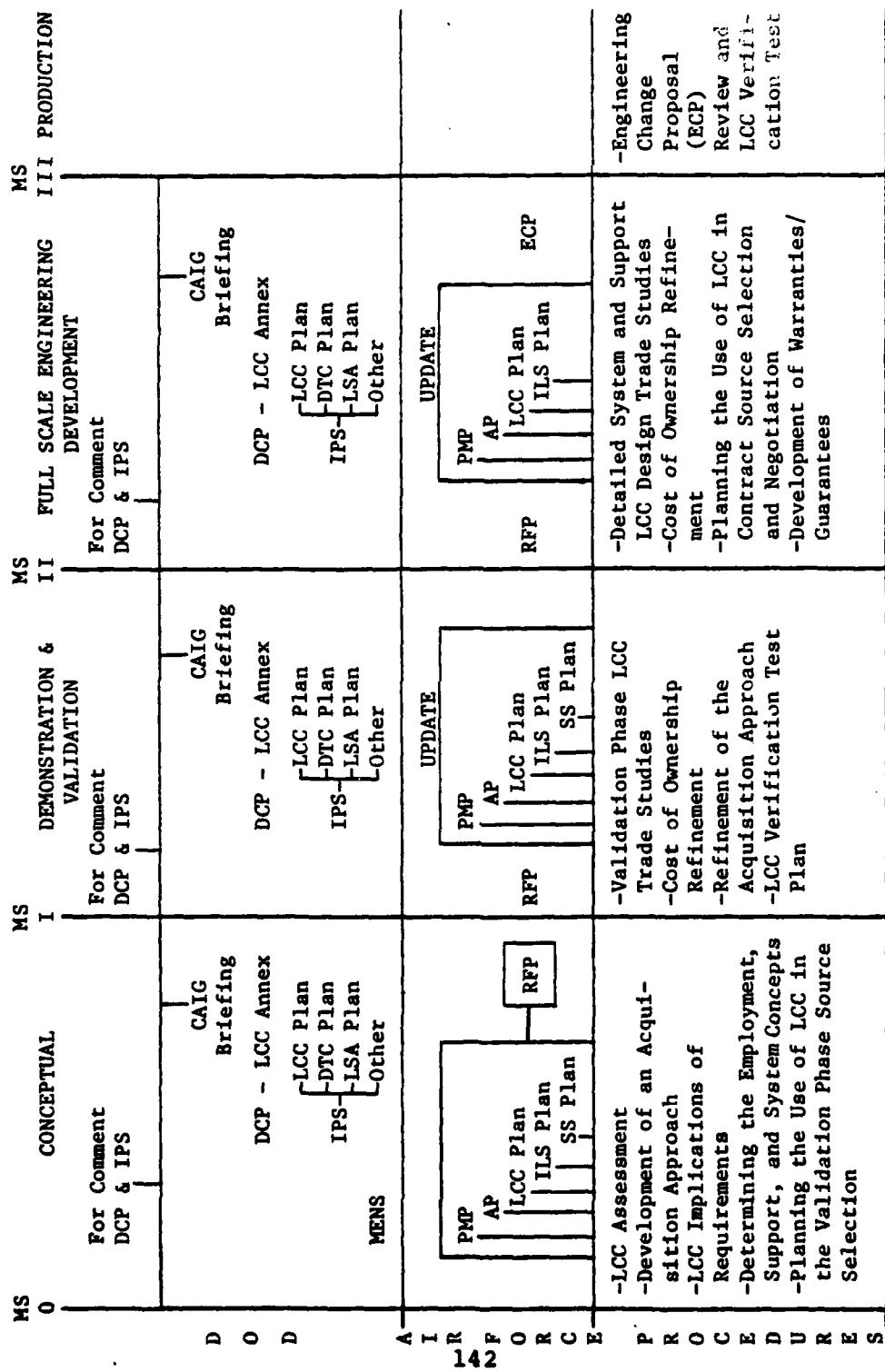


Fig. 17. Integration Chart: Requirements and Procedures

integrated information on the requirements, procedures, and techniques that impact his job. In accomplishing this objective, a number of germane findings about the LCC manager himself, his task, training, problems and organizational significance came to light.

The working level LCC manager is charged with an awesome task! He must understand the dynamics of system acquisition, interface with engineering design efforts, help develop integrated logistics support concepts, be conversant with numerous complex procedures and techniques, and be able to gather highly divergent data (reliability, failure mode, cost, use, etc.) and develop concise LCC statements that are suitable for use in everything from internal system tradeoffs to higher headquarters budget reporting! It might be expected that only the most experienced and highly trained managers would be given this difficult assignment.

The observations of this research team indicated otherwise. A large number of working level LCC managers interviewed in this study were highly motivated, but lacking in either previous acquisition experience or formal training. The most often cited formal training was a brief LCC overview course at the Air Force Institute of Technology and orientation from the ASD/ALD LCC Management Group. The underlying reasons for the inexperience among LCC working level managers appeared to be the rapid turnover of

personnel and a tendency to assign LCC responsibilities to fairly new personnel. This was particularly true in the smaller, less-than-major-system program offices. Program offices with greater inherent stability (Propulsion SPO and Simulator SPO, for example) seemed to have more ongoing LCC training and other initiatives.

The inexperience and turnover of working level LCC managers is particularly distressing in view of two primary responsibilities of the manager. First, the working level LCC manager must interface with system design engineers in order to influence supportability and decrease ownership costs. The vast majority of decisions affecting the support and ownership characteristics of a weapon system are made early in the acquisition cycle (see Figure 18). An inexperienced LCC manager has enough difficulty understanding the flood of basic acquisition requirements taking place in the Conceptual Phase, and may not be able to perform subtle coordination and interface actions with design engineers to positively influence supportability and cost performance. Second, the working level LCC manager must oversee contractor efforts. He does not have to be an expert in every procedure and technique used in LCC management. However, he must be able to ensure that the contractor is performing assigned analysis, trade studies, etc., in the correct fashion. Since civilian contractors are not subject to as rapid a turnover of LCC personnel or assign LCC

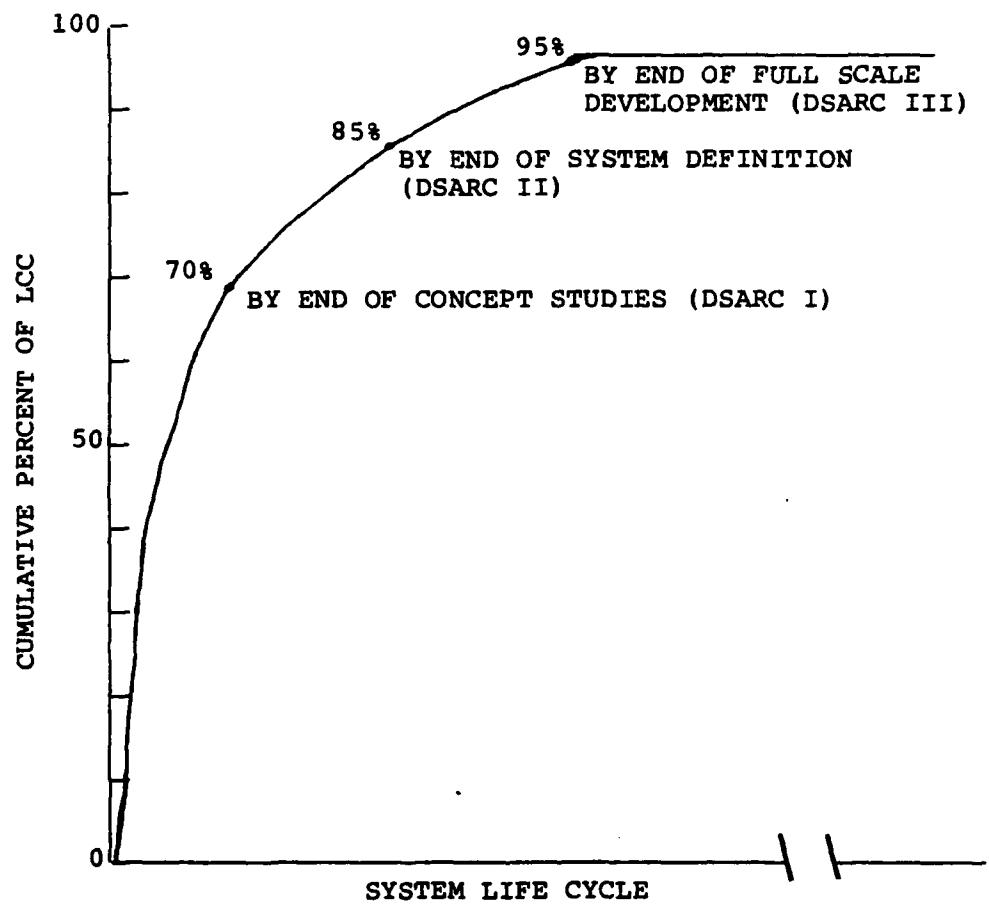


Fig. 18. Life Cycle Costing in System Acquisition (11:20)

duties to new managers, a growing disparity may exist between contractor and Program Office LCC personnel. This disparity engenders a dangerous situation where contractor LCC managers may "snow" inexperienced Program Office LCC managers, or subvert LCC requirements in order to save short-term dollars. Experienced contractor personnel can (and sometimes do) "game" the LCC system, and the SPO LCC manager must be capable of seeing through any such subterfuge.

Recommendation: The Working Level
• LCC Manager

To increase the training and job experience of working level LCC managers, several initiatives can be undertaken. At the top of the spectrum, changes in the personnel assignment process can be made to develop a cadre of experienced acquisition/LCC managers through personnel reassignment to procurement areas. At the local level, increased training and "apprenticeship" opportunities for new LCC managers would be appropriate.

"How-to" guidance, expanding on the material in this thesis, is needed. Such an initiative is underway in ASD/ACCL and should contribute positively to the need in this area. Presently, the ASD/ALD LCC Management Group is considered the expert concerning LCC matters. From the authors' research, it was evident that this office's manning needed to be increased to allow for an organizational

branch that encouraged LCC apprenticeship, LCC training, and development of LCC personnel to be matrixed to the individual program offices. This branch could also provide LCC analysis capability, backing up the managers in the program offices, as well as serving as the center for LCC technical development (model building, new analytical techniques, sample contract clauses, etc.).

Finding: The Data Problem

As revealed in the field interviews, the most pervasive problem the working level LCC manager faces is the lack of quality data to input into techniques and make decisions with. The impoverishment of data applies to the operating and support cost area. This lack of data leads to a number of serious problems. First, it necessitates that important tradeoff and supportability decisions be made with marginal amounts of data. Secondly, it forces LCC managers to spend excessive time and effort searching for data. Since different analysts may look in different places, it becomes difficult to compare estimates or findings across program lines or longitudinally in time. Finally, it defeats an LCC manager's ability to use feedback to evaluate how effective particular LCC strategies, procedures, and techniques were. This stifles development and improvement of basic LCC tools.

Recommendation: The Data Problem

Work on this problem is underway with VAMOSC II, the Product Performance Feedback System, and the Product Performance Agreement Center.

VAMOSC II (an AFLC responsibility) is an automated, data based system that will gather virtually all operating and support (O&S) cost data on certain Air Force systems and make the data available to users in flexible formats.

The Product Performance Feedback System (PPFS) (an AFALD responsibility) is an automated system that will gather logistics data (all the data currently collected on Logistics Support Analysis Records (LSAR)) and engineering data on past systems and equipment. Both of these systems, VAMOSC II and PPFS, are automated and are designed to interface with each other.

The Product Performance Agreement Center (PPAC) will be a central collecting organization for feedback data on the effectiveness of contract warranty and guarantee techniques.

The danger in these initiatives is that each will develop in separate directions and may not succeed in supporting the working level LCC manager. It is the recommendation of this research team that liaison elements from each of these systems, while they are still being developed, be established with the ASD/ALD LCC Management Group. This organizational move will help the data management

systems to evolve in a customer-oriented direction. It will also lay the groundwork for the next step, i.e., to have full time VAMOSC II, PPFS, and PPAC personnel in the LCC working group. This would greatly enhance LCC analysis support, help develop new models, procedures and techniques, and facilitate interface from data sources to users' models and analytical techniques (particularly computer based models and techniques). The arrangement would also promote feedback on the success of LCC tools directly into the development of new tools. The synergistic effect of such an arrangement would certainly increase the overall effectiveness of LCC in weapon system acquisition.

Future Changes

In terms of velocity of change, complexity of problems, and pressure to produce, the environment of the working level LCC manager is one of the most demanding in the Air Force. If signals from the present national administration for increased military spending are indeed what they seem to be, this situation will only increase in pitch.

From interviews at HQ USAF, it was communicated to these researchers that there will be increasing pressure to shorten the DSARC process. This is extremely significant to the working level LCC manager (10). The majority of decisions that permanently affect the supportability and ownership cost of a new system are made very early in the

life of the system (Conceptual Phase). If the DSARC process is shortened, the LCC manager will have even less time to plan LCC strategy, affect design for supportability, gather data and produce cost estimates for cost/performance/schedule tradeoffs.

If indeed an increased number of weapon systems are to be procured in the near future, this along with a reduction in the length of the DSARC process, could outstrip the current ability in many program offices to ensure supportable systems (10).

Recommendations for Further Research

As is often the case with research, more questions may be raised than are answered. The following areas are suggested for follow-on research efforts.

LCC Personnel Policies

The need in this area is to clearly identify present personnel policies for civilian and military LCC managers, and their impact on LCC effectiveness. The consequences of turnover rates, inexperience, and lack of progression inside the acquisition career field should be specifically addressed.

"How-to" Guidance

A more detailed treatment of the requirements, procedures and techniques, especially those cited in the

Conceptual Phase of the DSARC process, is needed. This is particularly important in view of the upcoming changes in DSARC process and the overwhelming importance of the Conceptual Phase to an effective LCC program. This recommendation is qualified with the knowledge that ASD/ACCL is currently working on a guide to cover each DSARC phase, to include sample clauses and analytical techniques. Automation of required techniques would also be extremely helpful. A study to develop an LCC decision support system would be beneficial (see below).

Data System Integration

A truly exciting development for the LCC manager is the parallel development of two useful automated data systems. A study is needed on how to integrate these developments (VAMOSC II and PPFS) with each other and interactively into LCC models and techniques. The study should use the principles of decision support systems, systems analysis, modeling, etc., to link users and data bases most effectively.

Software Acquisition

The cost and complexity of software and software support will probably grow faster than any single acquisition area in the near future. A study should be made on the adequacy of procedures and techniques to standardize,

cross-utilize, and support software. Especially needed are new warranty/guarantee clauses (see discussion in Chapter IV).

APPENDICES

APPENDIX A
INTERVIEW GUIDE

GENERAL

Q1. When you assumed your present duties, what stage was the program in?

A2. Did you receive any type of training or orientation in LCC after you assumed your duties?

Q3. After you started your present job, how did you become familiar with LCC concepts?

Read Regulations?

Read LCC Working Group Guides?

Talk to other persons? Who?

Q4. In your opinion, what is the commitment to LCC in the SPO?

Q5. How much LCC information did you get from the advanced development effort?

REQUIREMENTS

Q6. After the MENS was approved, (how did you or do you know how) the LCC strategy was developed in the SPO?

Q7. During the initial phases of the program, prior to release of the RFP, a Program Management Plan and Acquisition Plan of which one section concerns LCC management, have to be developed. How (did you or do you know how) this was accomplished?

Q8. Prior to the release of the RFP, a major effort is involved with System Engineering personnel trying to achieve a balance among operational, economic, and logistics factors. How (did you or do you know how) LCC was considered during this phase?

Q9. When the RFP was being developed, how (did you or do you know how) the LCC requirements were developed for the RFP?

Q10. When the RFP was being developed, did you contact AFALD/PT "Lessons Learned" for information?

Q11. During the Conceptual Phase, did you lay out an overall LCC strategy (i.e., ECP approval, verification testing)?

Q12. What part did you have in preparing the DCP for DSARC 1?

Q13. What other requirements do you perceive in your job that you are expected to meet for LCC?

Q14. During the RFP evaluation, did the contractor respond correctly to the RFP guidance concerning LCC?

PROCEDURES AND TECHNIQUES

In the (see Attachments 1-IV) phase we have defined general procedures a life cycle cost manager must employ to cover the requirements of the phase.

The procedures are: (Card to interviewee)
(Short discussion of procedures)

Q1. Can you point out any LCC requirement in this phase that these general procedures would not cover?

Each of the general procedures before you has associated with it certain techniques that may be useful in carrying out the procedure. I would like to review the procedures and associated techniques with you for your comments.

Q2. The procedure is _____. In your experience has this been a needed procedure for this phase?

To help carry out this procedure, the technique of _____ might be used.

Q3. Would this technique really be useful in helping carry out this procedure?

YES

Q4. If you employed this technique yourself, who or where would you go to for guidance or assistance?

Q5. If you did not employ the technique yourself, who would be responsible for its employment?

Q6. What problems have you encountered in association with this particular technique?

Q7. What practical advice would you like to pass on to future LCC managers that might make the use of this technique easier or better?

Q8. Where else during the system acquisition process might this technique be useful?

Q9. NO Why not?

Q10. When else during the system acquisition process might this technique be used?

OTHER QUESTIONS

Q11. What other quantitative techniques might be useful in carrying out this procedure?

Q12. What nonquantitative techniques would be useful in carrying out this procedure? (Discuss)

FINAL QUESTIONS

Q13. What other activities that we have not discussed would an LCC manager involve himself in to cover the requirements of this phase?

Q14. An LCC manager must interact and coordinate with various individuals and groups during each phase of the acquisition process. Describe the frequency and importance of the interacting during this phase with the following:

DPML:

Program Control:

System Engineers:

ILSM:

Projects:

AFALD XR:

AFALD Lessons Learned:

Contracts:

Cost Analysis:

AFALD/ASD LCC Working Group (Now called ASD/ACCL):

CONCEPTUAL PHASE

- A. LCC Assessment
 - 1. Specialist Estimates
 - 2. Risk Analysis
 - 3. CER/Parametric Cost Estimating
 - 4. USAF Cost and Planning Factors
- B. Development of an Acquisition Approach
 - 1. Cost Benefit Analysis
- C. LCC Implications of Requirements
 - 1. CER Model
- D. Determining the Employment, Support and System Concepts
 - 1. Level of Repair Analysis
 - 2. Logistics Performance Factors
- E. Planning the use of LCC in the Validation Phase
 - 1. Contingency Analysis
 - 2. Reliability Improvement Models

VALIDATION PHASE

- A. Validation Phase LCC Trade Studies
 - 1. Economic Analysis
 - 2. Cost Benefit Analysis
 - 3. Economic Analysis Model
 - 4. LCC Model
- B. Cost of Ownership Refinement
 - 1. Engineered Cost Estimating Method
 - 2. Specific Analogy
 - 3. Rates, Factors, Catalog Prices
 - 4. Trend Analysis
 - 5. R&M Analysis (Production and Allocation)
 - 6. Level of Repair Analysis
 - 7. Risk Analysis
 - 8. Sensitivity Analysis
 - 9. Accounting LCC Model
- C. Refinement of the Acquisition Approach
 - 1. Operating and Support Cost Factor Incentive Provision
 - 2. Award Fee Provision
 - 3. Logistics Support Cost Commitments Provision
- D. LCC Verification Test Plan
 - 1. Pre-Award Testing
 - 2. R&M Acceptance Testing
- E. Planning the Use of LCC in FSED

FULL-SCALE ENGINEERING DEVELOPMENT

- A. Detailed System and Support LCC Design Trade Studies
 - 1. Inventory Management Model
 - 2. LSA
- B. Cost of Ownership Refinement
 - 1. Sensitivity Analysis
 - 2. Risk Analysis
 - 3. LCC Accounting Model
 - 4. Engineered Cost Estimating Model
 - 5. R&M Analysis
 - 6. Trend Analysis
 - 7. Rates, Factors, Catalog Prices
 - 8. Learning Curve Analysis
- C. Planning the Use of LCC in Contract Source Selection and Negotiation
 - 1. Learning Curve Analysis
 - 2. LCC Model
- D. Development of Warranties/Guarantees Option Selection
 - 1. Warranty Model
 - 2. RIW/RIW with MTBF Guarantee
 - 3. Fixed Price with Incentive
 - 4. Support Cost Guarantee
 - 5. Reliability Demonstration Incentive
 - 6. Fixed Price Repair with Incentive

PRODUCTION PHASE

- A. Engineering Change Proposal Review
 - 1. ECP Model
 - 2. Value Engineering Incentive
 - 3. R&M Testing
- B. Life Cycle Cost Test Development
 - 1. LCC Test Plan
 - 2. LCC Model
 - 3. Inferential Statistics
 - 4. Learning Curve Analysis

APPENDIX B

VAMOSC II

A new system for gathering the total spectrum of O&S data and organizing it into categories useful to the various LCC procedures and techniques is scheduled to be operational soon. This system is called Visibility and Management of Operating and Support Costs, System II (VAMOSC II). VAMOSC II has three major subsystems, or modules: Weapon System Support Cost (WSSC) system; Communications-Electronics (C-E) system; and Component Support Cost System (CSCS). A description of each of these subsystems follows.

[WSSC]

The objective of the Weapon System Support Cost (WSSC) System is to provide DOD and USAF with visibility of operating and support costs for aircraft at the weapon system level. The system will collect and compute operating and support costs, provide a data base for a minimum of ten years, produce recurring reports, and provide access to the data base for demand type inquiries [41]. (More on this later.)

[C-E]

The second segment of VAMOSC is the Communications-Electronics (C-E) segment which parallels that of Weapon System Support Cost System. It is designed to provide DOD and USAF with visibility of operating and support costs for C-E equipment at the Type Model Series (TMS) level [41].

[CSCS]

The third segment of VAMOSC is the Component Support Cost System (CSCS). The objective of CSCS is to provide DOD and USAF with visibility of operating and support costs of aircraft and communications-electronics subsystems and components [41].

Tying together these three subsystems should produce a system with significant capability. One of the VAMOSC II directors states that the system will allow

. . . identification of high cost items, [providing] information for trade-off analysis and satisfying the operating and support cost requirements for DSARC. Additionally, it will be used by MAJCOMs to conduct trend analysis, identify high cost equipment management by them, and conduct analysis of the cost of like weapon systems in different geographical locations. The data base is being designed to provide users with the capability to conduct "what if" studies and the possibilities are only limited by the imagination of the questioner [18:3].

In Figure 19, the diagram of the system shows how VAMOSC II is configured, as viewed by these researchers. Each of the subsystem blocks will now be discussed.

User Demand. The VAMOSC II system will receive requests from various managers at all levels. Some demands might call for an identification of high cost items, data for cost trend analysis, or analysis of O&S cost for varying locations, support or operational concepts. The user can request practically any conceivable reclassification and combination of the historical data (18:2).

Interface Unit. To facilitate two-way communication between users and the system, a special corps of personnel will be used. These personnel will not only receive user requests but will also give expert advice on system capabilities and the various approaches to fulfilling the user needs.

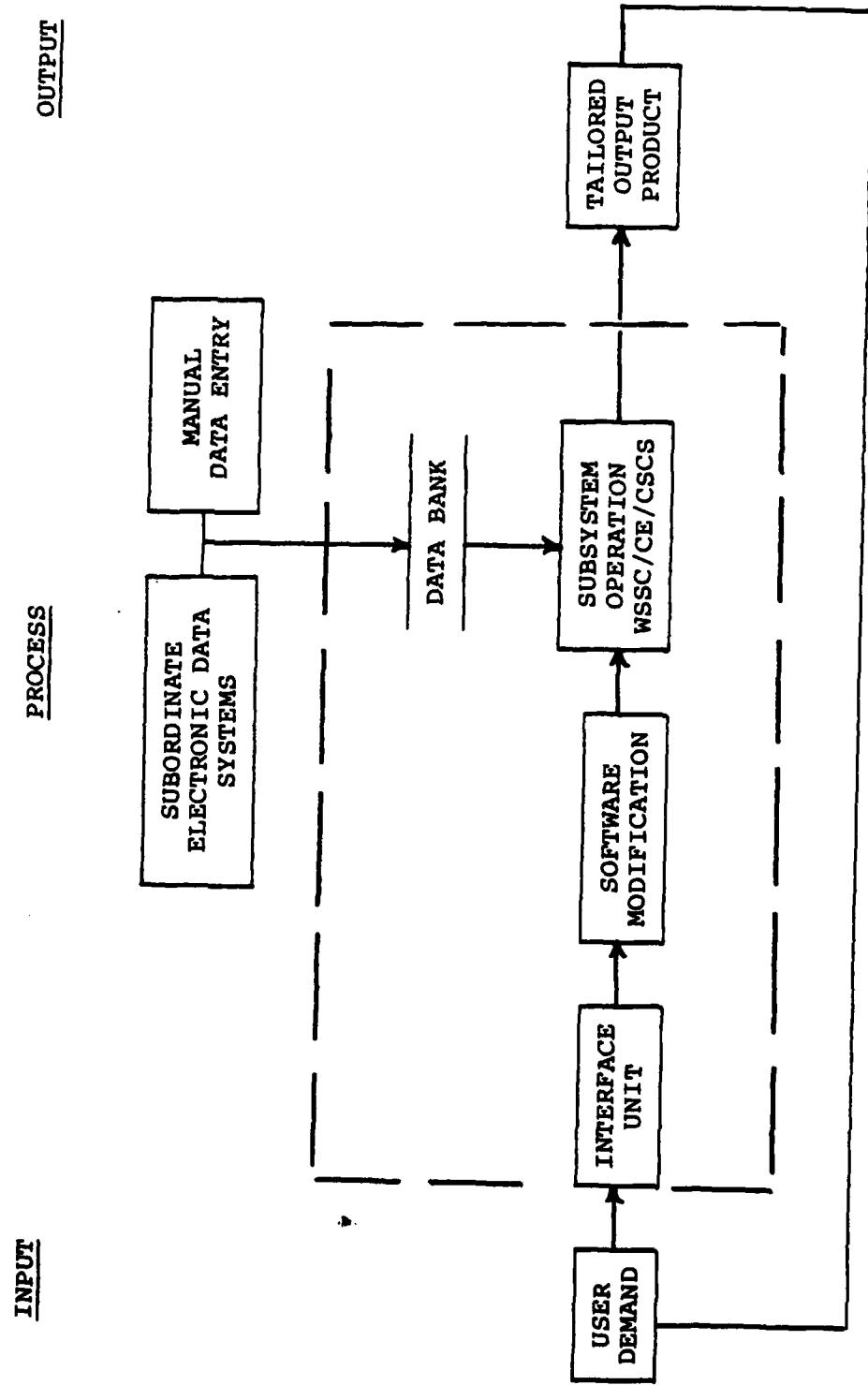


Fig. 19. VAMOSC II

Software Modification. To react to the user's special needs, a team of programmers will be maintained full time to design special software.

Subsystem Operation WSSC/CE/CSCS. One or more of the VAMOSC II subsystems will use either specially designed or "canned" software to process the user's request into a tailored package.

Data Bank. To build the tailored output package, the VAMOSC II subsystems will draw on an extensive data bank of O&S costs. This data bank will be built from dozens of automated and manual data systems.

Tailored Output Package. The output product will physically be in a form most easily usable to the customer (magnetic tape, cards, paper, etc.). The output will then be used by the customer to feed into his specific analysis tools (LCC model, etc.).

APPENDIX C

ACRONYMS

AFLC	Air Force Logistics Command
APPRO	Air Force Plant Representative Officer
AFR	Air Force Regulation
ASCS	Air Force System Command
AP	Acquisition Plan
ASD	Aeronautical System Division
CAIG	Cost Analysis Improvement Group
CAR	Command Assessment Review
CDRL	Contract Data Requirements List
CER	Cost Estimating Relationship
COD	Correction of Deficiency
DAR	Defense Acquisition Regulation
DCAS	Defense Contract Administration Service
DCP	Decision Coordinating Paper
DIA	Defense Intelligence Agency
DMO	Data Management Officer
DOD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
DSARC	Defense System Acquisition Review Council
DTC	Design to Cost
ECP	Engineering Change Proposal
FLU	First Line Unit
FMEA	Failure Mode and Effects Analysis

FSED	Full Scale Engineering Development
IES	Industrial Engineering Standards
ILS	Integrated Logistics Support
ILSP	Integrated Logistics Support Plan
IPS	Integrated Program Summary
LCC	Life Cycle Cost
LCCP	Life Cycle Cost Plan
LCOM	Logistics Composite Model
LPF	Logistics Performance Factors
LRCA	Long Range Combat Aircraft
LRU	Line Replaceable Unit
LSA	Logistics Support Analysis
LSAR	Logistics Support Analysis Record
MEA	Maintenance Engineering Analysis
MENA	Mission Element Need Analysis
MENS	Mission Element Need Statement
MIL-STD	Military Standard
MLSC	Measured Logistics Support Cost
MOD-Metric	Modified Multi-Echelon Technique for Recoverable Item Control
MTBF	Mean Time Between Failure
NMCS	Not Mission Capable Supply
ORLA	Optimum Repair Level Analysis
O&M	Operating & Maintenance
O&S	Operating & Support
OSD	Office of the Secretary of Defense

PAR	Program Assessment Review
PMD	Program Management Directive
PMP	Program Management Plan
PPAC	Product Performance Agreement Center
PPFS	Product Performance Feedback System
RFP	Request for Proposal
RIW	Reliability Improvement Warranty
R&M	Reliability & Maintainability
SOC	System Operational Concept
SON	Statement of Need
SPO	System Program Office
SSP	Source Selection Plan
TLSC	Target Logistics Support Cost
VAMOSC	Visibility and Management of Operating and Support Costs

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